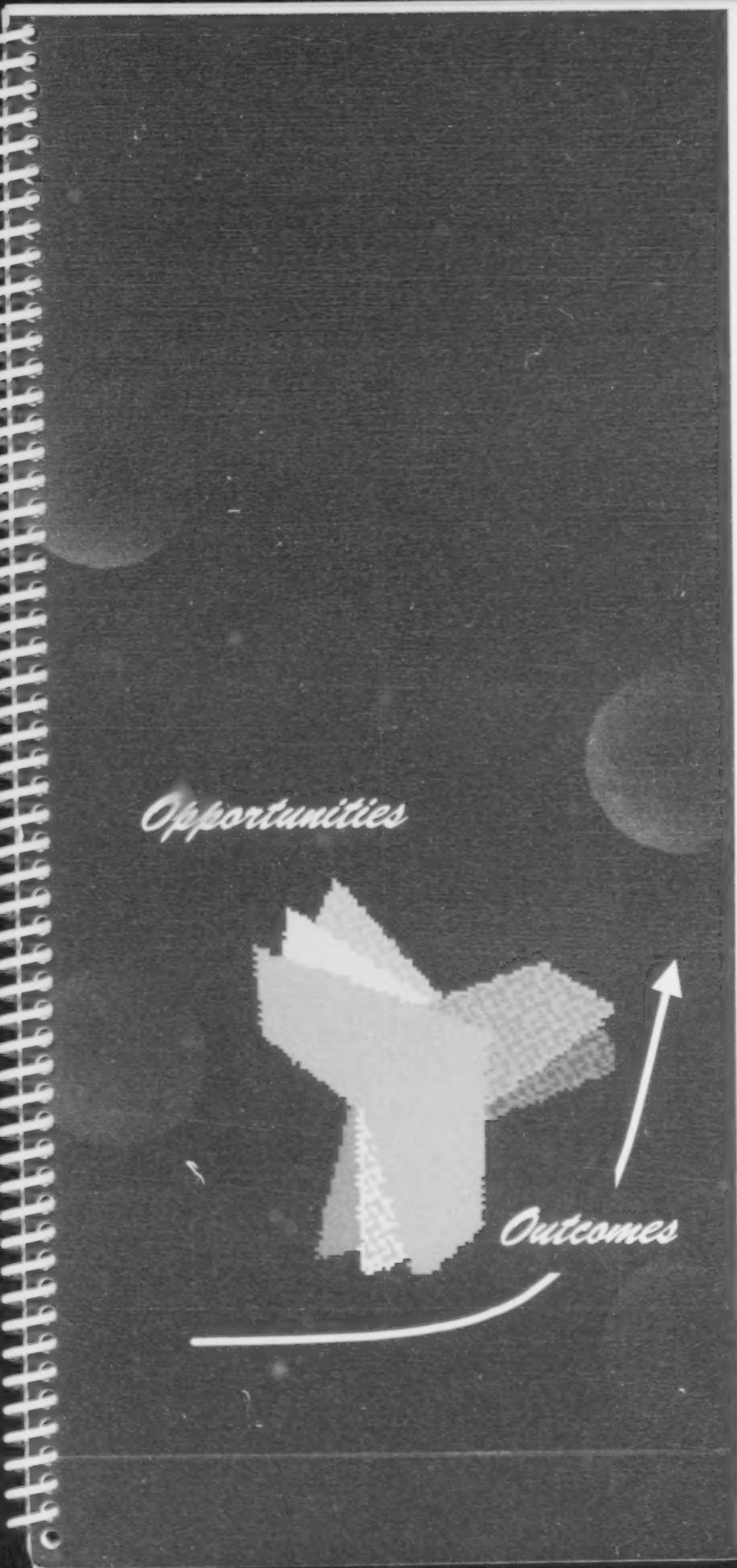


1997 Provincial Learning Assessment in Mathematics

January 1998

Saskatchewan Education

105-04546/

ACKNOWLEDGEMENTS

Saskatchewan Education would like to express its appreciation to the many people whose time, experience, expertise and commitment carried this project through to completion. Thanks are due to:

Deborah Agema
Allan Ausum
Ed Bourassa
Kathy Bracken
Marvin Brose
Gina Chan
Ron Chapdelaine
Lori-Jane Dowell-Hantelmann
Harold Fenske
Jeanne Fetsch
Liliane Gauthier
Ruth Griffiths
Blair Gullickson
Angela Harding
Cheryl Harvey
Jolene Holtvogt-Briens
Carolyn Johnson
Kathryn Johnson
Rachelle Lien
Lynda Longpré
Sharon Malley
Lyle Markowski
Isabelle McCrea
Barry Mitschke
Gary Morrison
Carla Natrasany
Wayne Neudorf
Bonnie O'Grady
Laurence Owen
Lexi Pace
Connie Rosowsky
Murray Sanders
Robert Slykhuis
Doug Sthamann
Maxine Stinka
Mark Stockham
Sally Struthers
Jennifer Wilson
Dr. Al Yackulic

As well, appreciation is extended to:

- the Saskatchewan teachers and students who participated in the 1997 Provincial Mathematics Learning Assessment;
- those who field-tested administration procedures, questionnaires and test instruments; and,
- the school-based administrators and school division administrators who assisted in preparing teachers and students for the administration of the assessment.

ISBN 0-921291-97-3

Table of Contents

List of Figures ..... *iii*

EXECUTIVE SUMMARY iv

I. INTRODUCTION 1

OBJECTIVES OF THE 1997 ASSESSMENT 1

SCOPE AND NATURE OF THE ASSESSMENT 2
Test Components 2
Student Participation 2
Students' Motivation to Do Well 3
Format of the Assessment 3
Limitations of the Assessment 3
Deciding Whether Student Opportunities or Outcomes are Sufficient 4

II. OPPORTUNITIES TO LEARN MATHEMATICS 5

OVERVIEW 5

CLASSROOM-RELATED OPPORTUNITIES TO LEARN 8
Opportunity to Use Manipulatives 9
Opportunity to Learn Mathematics in Small-Group Situations 10
Opportunity to Use Computers When Learning Mathematics 11

READINESS-RELATED OPPORTUNITIES TO LEARN 13
Opportunity to Learn Mathematics When Doing Homework 13
Persistence and Opportunity to Learn Mathematics 15

PARENTAL SUPPORT AND OPPORTUNITY TO LEARN MATHEMATICS 16

III. STUDENT ACHIEVEMENT 17

INTRODUCTION 17
Determining Student Achievement 17
Understanding Student Achievement from the Graphs 18

OVERALL ACHIEVEMENT: PERFORMANCE-BASED TESTS 20
The Nature of Performance-Based Tests 20
Grade 5 Performance Station Tasks 20
Grade 5 Overall Achievement Results 23
Grade 8 and 11 Performance Station Tasks 24
Grade 8 Overall Achievement Results 27
Grade 11 Overall Achievement Results 28

Communicating Mathematics Understanding 30
Factors Affecting the Assessment of Communication in Mathematics 30
Judging Written Communication in Mathematics 31
Results for Proficiencies in Communicating Mathematics Understanding 32

Comparing Achievement Among the grades for Common Tasks 33

Grade 5 Paper-and-Pencil Test Results 36
Computation Skills 36
Calculator Use and Computation Skills 37
Mathematics Content Skills 37
Problem-Solving Skills 39

IV. Student Achievement, Attitudes and Practices 41

Gender Differences in Achievement 41

Mathematics-Related Attitudes and Practices 44
Usefulness of Mathematics 44
Students' Attitudes in Mathematics 45
Relating Attitudes and Achievement 46

V. Conclusions and Next Steps 48

Appendices

Appendix A: Test Design and Results in 1997 and 1995 49
Appendix B: Sample Size and Profile 50
Appendix C: Administrative Methods and Procedures 51
Appendix D: Scoring and Data Analysis 52
Appendix E: Standard-Setting Procedures 54
Appendix F: Mathematics Criteria 56

References 58

List of Figures

Figure 1: Sources of Information for the Saskatchewan Education Indicators Program 1
Figure 2: Grade 5 Saskatchewan Students' Opportunities to Learn Mathematics 6
Figure 3: Grade 8 Saskatchewan Students' Opportunities to Learn Mathematics 6
Figure 4: Grade 11 Saskatchewan Students' Opportunities to Learn Mathematics 7
Figure 5: Use of Manipulatives, Expected and Actual Opportunities 9
Figure 6: Use of Small-Group Situations for Learning Mathematics, Expected and Actual Opportunities 10
Figure 7: Student Responses for Mathematics-Related Computer Use, Expected and Actual Opportunities 11
Figure 8: Teacher Satisfaction with Computer and Internet Use in Their Mathematics Classrooms 12
Figure 9: Time Spent Doing Mathematics Homework, Expected and Actual Opportunities 13
Figure 10: Average Time Spent Doing Mathematics Homework 14
Figure 11: Students' Mathematics Persistence, Expected and Actual Opportunities 15
Figure 12: Readiness-to-Learn Practices 15
Figure 13: Parents' Involvement in Their Children's Education 16
Figure 14: Grade 5 Performance-Based Test Results, Expected and Actual Outcomes 23
Figure 15: Grade 8 Performance-Based Test Results, Expected and Actual Outcomes 27
Figure 16: Grade 11 Performance-Based Test Results, Expected and Actual Outcomes 28
Figure 17: Grade 5, 8, and 11 Proficiencies in Communicating Mathematics Understanding, Expected and Actual Outcomes 32
Figure 18: Grade 5, 8, and 11 Comparisons, Expected and Actual Outcomes for the *Win or Lose* Station 33
Figure 19: Grade 5, 8, and 11 Graph of Expected and Actual Outcomes for the *Win or Lose* Station 34
Figure 20: Grade 8 and 11 Comparisons, Actual Outcomes for the *Sim Solids* and *Caters* Stations 35
Figure 21: Grade 5 Computation Skill Results by Question Type 36
Figure 22: Grade 5 Computation Skills, Frequency Distribution 36
Figure 23: Grade 5 Multiple-Choice Test Results 38
Figure 24: Grade 5 Problem-Solving Test Results, Expected and Actual Outcomes 40
Figure 25: Average Scores of Females and Males, 1997 Provincial Mathematics Performance-Based Tests 41
Figure 26: Attainment of Good Mathematics Proficiency Levels, 1997 Provincial Mathematics Performance-Based Tests 42
Figure 27: Average Scores of Females and Males, Individual Performance Stations 42
Figure 28: Grade 5 Paper-and-Pencil Average Test Scores, Females and Males 43
Figure 29: Usefulness of Mathematics Content and Processes, Student Responses 44
Figure 30: Students' Attitudes in Mathematics 45
Figure 31: Average Scores of Students Related to Their Attitudes 46
Figure 32: Achievement by Attitude and Gender 47
Figure 33: Grade 5 Average Scores for Computation Skills and Content Skills, *1997 and 1995 Provincial Mathematics Learning Assessments* 49
Figure 34: Sample Size and Profile, *1997 Provincial Mathematics Learning Assessment* 50

Executive Summary

In May 1997, 2300 Grade 5, 8, and 11 Saskatchewan students from 106 randomly-selected schools participated in the *1997 Provincial Mathematics Learning Assessment*. This was the second such mathematics assessment. The first was in 1995 with the report released in October 1996.

Opportunities to Learn Mathematics

A standard-setting panel representing various education partners set provincial expectations for the students' "opportunities to learn" in mathematics. Student questionnaire information indicates:

- Most Saskatchewan students do not have sufficient opportunity to learn mathematics by:
  - using "hands-on" manipulatives;
  - working in small-group situations;
  - using the computer; and,
  - spending sufficient time doing mathematics homework.
- Students are exceeding provincial expectations for their persistence when working on difficult mathematics questions. Other indicators of students' readiness to learn show that few students come to class with goals and a commitment to stay on-task.
- Students report good support for learning from their parents. While fewer than expected parents attend school interviews, the numbers who regularly talk with and help their children exceed provincial expectations.

Outcomes of Student Learning in Mathematics

About 1700 of the sampled students completed performance-based tests. These tests required a "hands-on" approach when considering possible solutions to practical problems. Students could attain one of five levels of achievement. *Level 5* is the highest and *Level 1* is the lowest. Achievement at *Level 3* or better represents good mathematics proficiency. Standards were set for the percentages of students at Grades 5, 8, and 11 expected to attain each achievement level. For overall application of numeracy, creative and critical thinking, and communication skills on the performance-based tests:

- The percentage of Grade 5 students attaining good mathematics proficiency met provincial expectations.
- The percentages of Grade 8 and Grade 11 students attaining good mathematics proficiency were below provincial expectations.
- The numbers of students achieving top level proficiency at Grades 5, 8, and 11 fell short of provincial expectations.

Students' skills at communicating their mathematics understanding were specifically measured. We found that:

- The numbers of Grade 5, 8, and 11 students demonstrating adequate communication of their mathematics understanding were below provincial expectations.
- Grade 11 students met provincial expectations for the number achieving proficient communications in mathematics. Fewer than expected Grade 5 and 8 students achieved this top level of communications.

Grade 8 and 11 students wrote paper-and-pencil tests designed and administered through the School Achievement Indicators Program. These tests were developed by the Council of Ministers of Education, Canada to assess the mathematics content knowledge and problem-solving skills of Canada's 13- and 16-year-olds. The paper-and-pencil test results for the achievement of Grade 8 and 11 students can be found in the School Achievement Indicators Program *Mathematics Report*.

However, over 600 Grade 5 students wrote provincially-developed paper-and-pencil tests. These tests assessed students' computation skills, content-mastery skills, and problem-solving skills.

- Grade 5 students closely approached provincial expectations for good mathematics proficiency on the paper-and-pencil, problem-solving test. Less than half the number expected to reach top level proficiency did so.
- Grade 5 students' computation skills match closely the results of the *1995 Provincial Mathematics Learning Assessment*. Whether or not students regularly use calculators when doing mathematics, their computation skills are the same.
- Results on the multiple-choice test show Grade 5 students lack mastery and application of many concepts, procedures, and relationships. This is particularly true for fractions and geometry. These results are consistent with those found in the *1995 Provincial Mathematics Learning Assessment*.

Other findings about students' attitudes and achievement include:

- Most students believe their classroom mathematics is useful.
- Most Grade 5 students like mathematics and are confident in their abilities. Fewer Grade 8 and Grade 11 students report such attitudes.
- On average, students who like mathematics and those who are confident when doing mathematics achieved higher scores than their counterparts.
- Females achieved higher scores than males in most areas of the assessment. This was particularly true for written communications in mathematics.

1. Introduction

What are the opportunities for Saskatchewan students to learn mathematics, and what are the outcomes of that learning? The 1997 Provincial Learning Assessment in Mathematics yielded mixed results, both in opportunities and in outcomes. The Assessment provides a second snapshot of student achievement in, attitudes toward, and practices related to numeracy. The first was provided by the 1995 Provincial Mathematics Assessment.

In May 1997, Grades 5, 8, and 11 Saskatchewan students completed questionnaires and tests demonstrating their attitudes, practices, mathematics knowledge and problem-solving skills. This report summarizes these findings. It also examines factors related to students' opportunities to learn mathematics and their achievements.

The Provincial Learning Assessment in Mathematics is one source of information for the Saskatchewan Indicators Program. The Indicators Program draws data from many areas to create a comprehensive picture of Saskatchewan's K to 12 education system.

Figure 1: Sources of Information for the Saskatchewan Education Indicators Program

Saskatchewan Education Indicators Program
Statistics Canada Data
Saskatchewan Curriculum Evaluation Program
Provincial Learning Assessment in Language Arts (Reading and Writing)
Directors of Education Indicators Survey
Provincial Learning Assessment in Mathematics
International Assessments and Surveys
Other Data Sources
Council of Ministers of Education, Canada (CMEC) Indicators Programs

Objectives of the 1997 Assessment

The objectives of this mathematics assessment were to:

- report to the people of Saskatchewan on students' mathematics abilities and thinking skills;
- assess student achievement levels and growth over time;
- collect information about the home and school environment contributing to students' opportunities to learn mathematics; and,
- compare student achievement with the 1995 Mathematics Assessment, where possible, and to provide comparative data for future assessments.

Scope and Nature of the Assessment

Test Components

Two methods were used to measure mathematics achievement at Grades 5, 8, and 11:

- A paper-and-pencil component gathered achievement data on mathematics knowledge and problem-solving skills.
- A performance-based or practical applications component provided hands-on opportunities when considering possible solutions to problems.

Students had opportunity to show their general numeracy skills, creative and critical thinking, and proficiency in communicating mathematics understanding. They integrated and applied skills from several areas of Core mathematics curriculum. Consequently, information was not collected within the various curricula strands.

Student Participation

Classrooms from a random sample of 106 schools in urban, rural, and northern Saskatchewan were selected. Students completed either the paper-and-pencil component or the performance-based component, not both.

Students enrolled in regular mathematics programs participated. Students in modified programs, where foundational objectives of the course have been altered, did not participate. In other words, students in special resource room programs, general mathematics classrooms, locally-developed programs, or International Baccalaureate (I.B.) programs were **not** assessed. Regular program students requiring adaptations such as large-print forms, readers, and scribes did participate.

Details of sample selection, sample size, and sample profile are included in *Appendix B*.

In 1997, Saskatchewan participated with the other provinces and territories in the School Achievement Indicators Program (SAIP) Mathematics Assessment. The SAIP assessment, developed by the Council of Ministers of Education, Canada (CMEC) was administered to 13- and 16-year-olds. It supplied the paper-and-pencil tests for Grade 8 and 11. Achievement results for 13- and 16-year-olds are reported in the *SAIP Mathematics Report*.

This Provincial Learning Assessment Report summarizes student achievement for:

- **the performance-based component for each of Grades 5, 8, and 11; and,**
- **the paper-and-pencil component for Grade 5.**

Performance-based tests were completed by:

- 528 Grade 5 students;
- 612 Grade 8 students; and,
- 528 Grade 11 students.

Paper-and-pencil tests were completed by:

- 613 Grade 5 students; and,
- 2000 students at each of ages 13 and 16 (wrote the national SAIP tests).

Students' Motivation to Do Well

Students were asked to try their best to show how well Saskatchewan students do in mathematics. Students' choice to do so depended on intrinsic motivation and personal satisfaction. Their work and effort on these tests did not affect their marks.

We report results only at the provincial level. We do not identify individual student, classroom, school, or school division information.

Format of the Assessment

The Grade 5 paper-and-pencil tests involved 2½ to 3 hours work over two consecutive days. The first day, students completed the computations part (8 questions) and the multiple-choice part (40 questions). The second day, students completed the six-problem, open-response test.

Teachers administered the performance-based component during one 2½-hour time period. The test required students to rotate through six performance stations.

Assessments were administered between April 28th and May 16th in the classroom by the teacher or a school-designated coordinator. Students completed a questionnaire about their attitudes toward and practices in mathematics. Teachers answered a similar questionnaire on their beliefs, practices, and perceptions related to mathematics.

Limitations of the Assessment

Some important aspects of student learning were difficult to include in this large-scale assessment. They are more appropriately measured by classroom teachers using direct observation, portfolios, journals, and interviews. Specifically, group problem-solving skills were not assessed. Also, students were not directly observed while performing tasks. Rather, student achievement was gauged from written responses in the test booklets.

- The computations and multiple-choice parts of the Grade 5 assessment were developed by selecting and re-working some items used in the 1995 Provincial Mathematics Learning Assessment.

- A group of Saskatchewan teachers developed test materials for the performance stations in the summer of 1996. They followed specifications set by a project team of curriculum specialists.

- In fall 1996, tests were piloted in a dozen urban, rural, and northern schools in Saskatchewan. Questions, problems, and performance stations were then refined or replaced, and administrative procedures were modified, based on teacher and student feedback.

Deciding Whether Student Opportunities or Outcomes are Sufficient

We invited stakeholders to send representatives to set standards related to:

- students' opportunities to learn mathematics; and,
- student achievement outcomes.

These representatives formed the standard-setting panel. In this report, they are identified as standard-setters or panelists. This group of parents, teachers, directors, and trustees considered the full context of the assessment. They:

- reviewed factors affecting students' opportunities to learn mathematics;
- attempted some of the test items and tasks;
- viewed examples of student work at various achievement levels; and,
- discussed students' opportunities and how well students would do.

The standards they set are the expectations for opportunities to learn and outcomes. The report presents student questionnaire and achievement information alongside these expectations. Appendix E details the standard-setting procedures.

II. Opportunities to Learn Mathematics

Has each student been given a fair opportunity to learn mathematics? Differences in students' learning experiences and not just in their ability to master concepts contribute to differences in achievement. Fair and sufficient opportunity depends on:

- good curricula;
- instructional time and materials;
- technologies;
- a variety of effective instructional strategies;
- educators with access to professional development;
- safe and secure school facilities; and,
- school policies that ensure non-discrimination.

Students and teachers completed questionnaires asking about their practices, attitudes, motivation, and the varying opportunities and contexts in which they learn to be numerate. Learning mathematics is a shared responsibility of the school, teacher, student, and parent. Standards were established for:

- classroom practices in mathematics;
- student readiness and commitment to learn; and,
- parental support for learning mathematics.

Overview

The standard-setting panel considered eight opportunity-to-learn elements. For four elements, the standard stated the least number of times per week that students:

- use manipulatives in the classroom;
- work in small-group situations in the classroom;
- use the computer as a resource for learning mathematics; and,
- engage in mathematics homework.

For the final four elements, the standard indicated the expected percentage of students:

- who persist to their best ability when working on difficult mathematics questions;
- whose parents attend school interviews;
- whose parents discuss academic progress with them; and,
- whose parents help them with school assignments.

So, how do students' reported opportunities compare with these standards? The graphs in Figures 2, 3, and 4 show results for Grades 5, 8, and 11.

Figure 2: Grade 5 Saskatchewan Students' Opportunities to Learn Mathematics

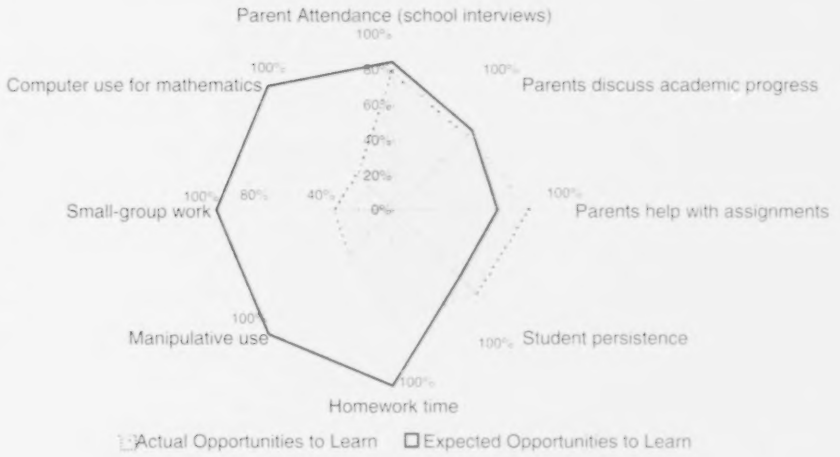
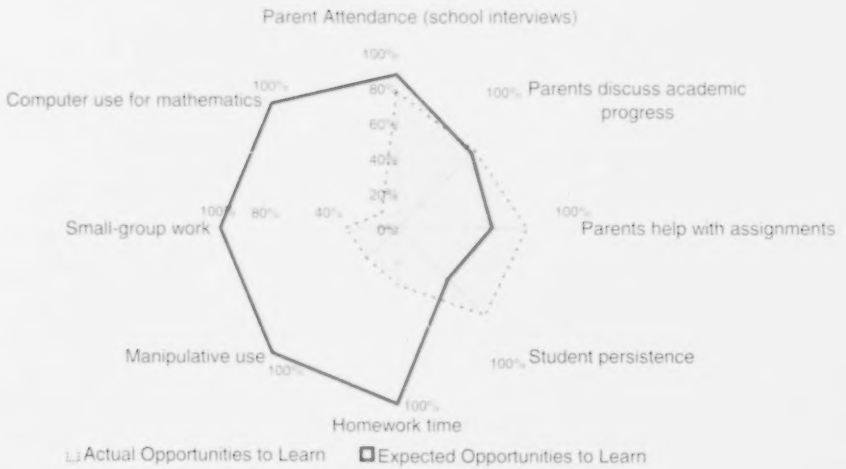


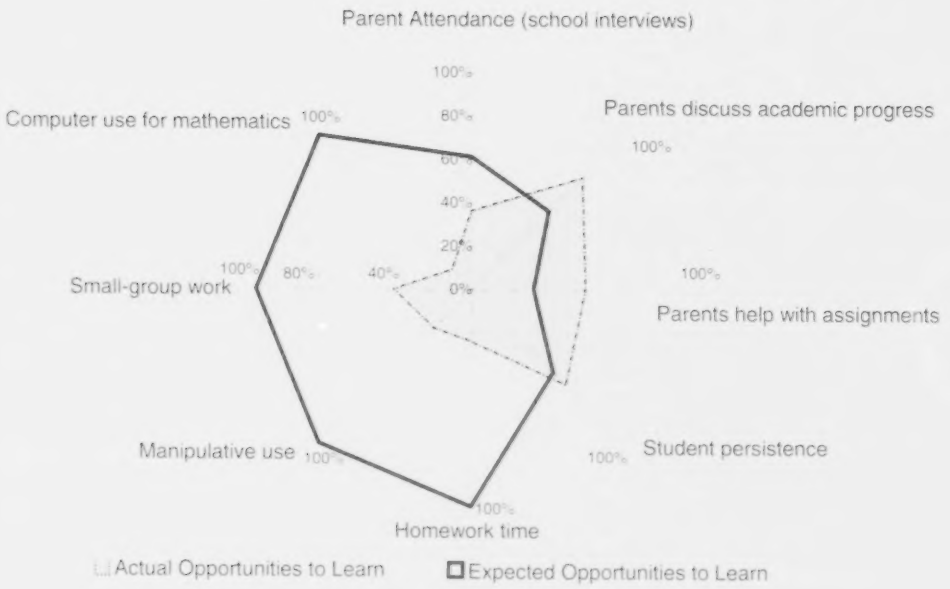
Figure 3: Grade 8 Saskatchewan Students' Opportunities to Learn Mathematics



How to interpret the figures

- *Each of the eight opportunity elements are placed along an axis.*
- *The standard for an element is where the dark boundary line intersects the axis. The figures show an expectation that 100% of students will use manipulatives, work in small groups, use computers, and do mathematics homework as frequently as the standard states.*
- *Students' reported opportunities are represented by the shaded region.*
- *Actual opportunities **fall short** of expectations if there is any white area along an axis inside the dark boundary line.*
- *Actual opportunities **exceed** expectations if the shaded region extends along any axis beyond the dark boundary line.*

Figure 4: Grade 11 Saskatchewan Students' Opportunities to Learn Mathematics



The figures show that:

- Saskatchewan students have insufficient opportunity to use "hands-on" manipulatives in classrooms.
- Only one-third of Saskatchewan students work in small groups as frequently as expected when learning mathematics.
- Fewer classrooms than expected have or use computers for learning and exploring mathematics.
- The number of students spending sufficient time doing mathematics homework falls short of provincial expectations. This is especially true at the higher grades.
- Saskatchewan students are exceeding expectations in terms of persistence in completing difficult mathematics questions.
- The number of parents attending school interviews does not meet the provincial standard, particularly for parents of Grade 11 students.
- Parents are meeting or exceeding expectations in discussing academic progress with their children.
- The percentage of parents who create opportunities to learn mathematics by helping their children with school assignments exceeds expectation.

Classroom-Related Opportunities to Learn

In the document, *Curriculum and Evaluation Standards for Mathematics* (1989), the National Council of Teachers of Mathematics recommends:

- hands-on active learning with access to and use of manipulatives;
- small-group classroom activities allowing students to exchange ideas and communicate their mathematics understanding; and,
- appropriate use of technology including calculators, computers, and videos allowing students to concentrate on problem-solving.

Panelists set standards related to these recommendations for each of Grades 5, 8, and 11. They determined the **least number of times per week** students would:

- use manipulatives;
- work in small-group situations; and,
- use the computer to learn mathematics.

The use of manipulatives, small-groups, and computers may be integrated. For instance, students may work cooperatively in groups to solve fraction problems using manipulatives. The session may last only twenty or thirty minutes. This would address both the standard for manipulative use and the standard for small-group work.

Opportunity to Use Manipulatives

Manipulatives are tools which students handle to understand and solve mathematics problems. Fraction blocks and base-ten materials help students understand number concepts. Fraction strips, algebra tiles, and graphing calculators let students see mathematics operations in action. Using materials to generate data or to test strategies provides context and meaning when solving problems.

Stakeholder representatives expect more frequent use of manipulatives in mathematics classrooms.

Figure 5: Use of Manipulatives, Expected and Actual Opportunities

	Expected Opportunity to Use Manipulatives	*Actual Opportunity to Use Manipulatives*		*No Use of Manipulatives*
	(Frequency Standard)[1]	*Student*[2]	*Teacher*[3]	*Student*
Grade 5	2.0 times/wk	36%	49%	32%
Grade 8	1.8 times/wk	24%	27%	56%
Grade 11	1.0 times/wk	25%	52%	75%

[1]Frequency Standard is the minimum expected number of times used per week.
[2]Percentage of students using manipulatives as frequently as the standard.
[3]Percentage of teachers giving opportunity to use manipulatives as frequently as the standard.

Figure 5 shows that:

- About one-third of Grade 5 students and only one-quarter of Grades 8 and 11 students report having the expected opportunity to use manipulatives.

- Large numbers of students report never having the opportunity to use manipulatives. The percentage of these students rises from 32% in Grade 5 to 75% in Grade 11.

- Standard-setters expect more frequent use of manipulatives in Grades 5 and 8 than Grade 11.

Other related findings include:

- Manipulatives are used more frequently in Grade 5 mathematics classrooms. Grade 5 students report, on average, using manipulatives 1.3 times per week.

- Grade 8 students report using manipulatives less than once per week. Grade 11 students do so less than once every two weeks.

Figure 5 also shows different student and teacher perceptions about opportunities to learn. The differences may derive from different meanings they have for the word "manipulative." For example, Grade 11 teachers may consider graphing calculators as manipulatives and their students may not.

Opportunity to Learn Mathematics in Small-Group Situations

Most students do not work in small groups as frequently as expected.

Small-group classroom activities allow students to cooperatively solve problems and communicate their mathematics understanding.

Figure 6: Use of Small-Group Situations for Learning Mathematics, Expected and Actual Opportunities

	Expected Opportunity to Work in Small Groups	*Actual Opportunity to Work in Small Groups*		*Never Work in Small Groups*
	(Frequency Standard)[1]	*Student*[2]	*Teacher*[3]	*Student*
Grade 5	2.6 times/wk	34%	61%	14%
Grade 8	2.6 times/wk	29%	50%	26%
Grade 11	2.0 times/wk	36%	43%	37%

[1]Frequency Standard is the minimum expected number of times used per week.
[2]Percentage of students working in small groups as frequently as the standard.
[3]Percentage of teachers giving opportunity to work in small groups as frequently as the standard.

Figure 6 shows that:

- About one-third of Saskatchewan students report working in small groups as frequently as expected. Half of the teachers report providing such opportunity.

- Most Grade 5 students work with peers at least once a week. However, one-quarter of Grade 8 students and one-third of Grade 11 students report never doing so for mathematics.

Other related findings include:

- Opportunities to work with peers decline as students advance to higher grades. Grade 5 students report doing so 1.7 times per week. This is reduced to 1.5 times per week for Grade 8 students, and 1.3 times per week for Grade 11 students.

- Students more frequently learn mathematics by:
  - listening to teachers' instruction;
  - copying notes from the board or overhead; or,
  - working individually on worksheet or textbook exercises.

- About 15% of Grade 5 students, 30% of Grade 8 students, and 35% of Grade 11 students stated they learned mathematics most easily when they worked on problems with other students. About one-half of these same students reported working in small groups at least twice per week.

- More students in Grade 11 than Grades 5 and 8 prefer to learn mathematics in small groups. Fewer have such opportunity.

Opportunity to Use Computers When Learning Mathematics

Computer use as remedial, drill-and-practice or game-related instruments has greatly expanded. Computers are now used for mathematics exploration, group problem-solving, and activity-based, curricula-related programs. The internet provides opportunities for teachers and students to:

The potential of the computer is not being realized in the mathematics classrooms of Saskatchewan.

- use or engage in lesson plans;
- access chat sites and forums to discuss teaching ideas or seek understanding of problems; and,
- visit countless sites offering problems, activities, games, and exploration related to mathematics skills and applications.

Figure 7: Student Responses for Mathematics-Related Computer Use, Expected and Actual Opportunities

	Expected Opportunity to Use Computers	***Any Math-related Use of Computers***	
	(Frequency Standard)[1]	***Computer***[2]	***Internet***[3]
Grade 5	1.0 times/wk	41%	17%
Grade 8	0.7 times/wk	17%	7%
Grade 11	1.1 times/wk	17%	8%

[1]Frequency Standard is the minimum expected number of times used per week.
[2]Percentage of students reporting any use of computers for mathematics.
[3]Percentage of students reporting any use of the internet for mathematics.

Figure 7 shows that:

- The standard-setting panel expects that Grade 5 and 11 students would use the computer for mathematics learning at least once per week. They expect Grade 8 students to use them less frequently.

- Very few students, particularly at Grades 8 and 11, had used computers for mathematics. They reported school and/or home use but not the frequency of use. Most do not have the expected opportunity to use computers when learning mathematics.

We asked teachers whether they were satisfied with the use of the computer and the internet as learning resources in their classrooms. Those not satisfied were to indicate the primary reason for the insufficient use of the resource.

Figure 8: Teacher Satisfaction with Computer and Internet Use in Their Mathematics Classrooms

	Math-Related Computer Use				***Math-Related Internet Use***			
	satisfied	*lack access*	*need in-service*	*not useful*	*satisfied*	*lack access*	*need in-service*	*not useful*
Grade 5	24%	56%	16%	4%	2%	62%	34%	2%
Grade 8	12%	72%	16%	0%	8%	62%	23%	8%
Grade 11	13%	52%	30%	4%	26%	39%	30%	4%

Figure 8 shows that:

- Over 95% of teachers think the computer is a useful resource for learning and applying mathematics.
- Only one-quarter of Grade 5 teachers, and less than 15% of Grade 8 and 11 teachers are satisfied with the extent of the computer's use.
- Where 26% of Grade 11 teachers are satisfied with internet use in their mathematics classroom, only 8% of Grade 8 teachers and 2% of Grade 5 teachers feel the same.
- About 60% of teachers were unsatisfied with the use of computers in their mathematics classroom, primarily because of the lack of access to these resources.
- A lack of training was frequently identified as the main limitation to effective use of computers in mathematics classrooms. This was the response of over 15% of Grade 5 and 8 teachers and twice as many Grade 11 teachers.
- A lack of access and a need for in-service also limited the effective use of the internet in the mathematics classroom.

The graphing calculator offers useful functions for exploring mathematics at Grade 11. Although it lacks the versatility of the computer, the standard-setting panel thought it important to include its use when measuring students' opportunities to use technology when learning mathematics. Information specific to graphing calculators was not gathered in the 1997 Provincial Mathematics Learning Assessment.

Readiness-Related Opportunities to Learn

Students opportunities to learn are shaped by attitudes, values and commitment to learn. Two factors, homework practices and student persistence, are discussed in this section.

Opportunity to Learn Mathematics When Doing Homework

The number of students spending sufficient time doing mathematics homework falls short of provincial expectations.

Time spent doing mathematics homework is an indicator of a student's commitment to learn. A number of factors influence the time students spend doing homework. These include teacher expectations, the nature and purpose of the homework, the abilities of the student, and the discipline and coping skills of the student.

This study is limited to discussing expectations for the time spent doing mathematics homework. It does not address the nature of assigned homework, its completion, nor the quality of student work. Educators consider these aspects when they discuss questions such as:

- Do the homework assignments concentrate primarily on drill-and-practice?
- Are students challenged to apply their mathematics to novel situations?
- Are homework activities varied to meet the needs of students with different abilities and interests?
- Do students have the opportunity to work in groups for some assignments?

Figure 9: Time Spent Doing Mathematics Homework per Week, Expected and Actual Opportunities

	Expected Opportunity for Math Homework	***Actual Opportunity for Math Homework***	
	(Standard)[1]	***Student***[2]	***Teacher***[3]
Grade 5	0.7 hours/wk	64%	45%
Grade 8	1.5 hours/wk	32%	22%
Grade 11	2.6 hours/wk	24%	4%

[1]Standard is the recommended time spent each week.
[2]Percentage of students spending at least as much time as the standard indicates.
[3]Percentage of teachers who think most of their students spend at least as much time as the standard indicates.

Figure 9 shows that:

- Expectations for the time spent doing mathematics homework increases as students advance to higher grades.

- Two-thirds of Grade 5 students indicate spending at least the expected 0.7 hours per week doing mathematics homework. Only one-third of Grade 8 students and one-quarter of Grade 11 students report meeting their standard of 1.5 hours per week and 2.6 hours per week respectively.

Other related findings include:

- One-half of Grade 8 students and two of every five Grade 11 students report spending less than one hour per week doing mathematics homework.

About 7% of students at all grades report spending more than four hours per week doing mathematics homework.

Figure 10: Average Time Spent Doing Mathematics Homework

	Provincial Standard[1]	***Classroom Teacher Expect'ns***[2]	***Classroom Teacher Beliefs***[3]	***Student Practices***[4]
Grade 5	0.7 hours/wk	1.0 hours/wk	0.7 hours/wk	1.4 hours/wk
Grade 8	1.5 hours/wk	1.5 hours/wk	1.0 hours/wk	1.4 hours/wk
Grade 11	2.6 hours/wk	2.3 hours/wk	1.2 hours/wk	1.7 hours/wk

[1]Expectations set by the standard-setting panel of stakeholder representatives.
[2]Averages of teacher questionnaire responses reporting the time they expect students to spend doing mathematics homework.
[3]Averages of teacher questionnaire responses reporting the time they believe most of their students spend doing mathematics homework.
[4]Averages of student responses reporting the time they spend doing mathematics homework.

Figure 10 shows that:

- The provincial standards for mathematics homework time are similar to classroom teacher expectations for each of the grades.

- The average time Grade 5 students spend doing mathematics homework is twice provincial expectations. Grade 8 students, on average, meet provincial expectations for homework time. Grade 11 students do not.

- Teachers believe students spend 30-50% less time doing mathematics homework than they expect.

- Students report doing more homework than what teachers believe, but short of classroom teacher expectations. The exception is Grade 5 where students do significantly more than expected.

Persistence and Opportunity to Learn Mathematics

A second indicator of students' readiness to learn is their persistence in trying hard and using different strategies until they either solve difficult questions or do the best they can. This is an attitude and skill developed through practice, encouragement, and discipline.

Students are exceeding expectations in terms of persistence in completing difficult mathematics questions.

Figure 11: Students' Mathematics Persistence, Expected and Actual Opportunities

	Expected Opportunity	*Actual Opportunity*	
	(Standard)[1]	*Student*[2]	*Teacher*[3]
Grade 5	54%	70%	72%
Grade 8	41%	67%	65%
Grade 11	54%	62%	54%

[1]Percentages of students expected to persist to their best completion of difficult math questions.
[2]Percentages of students who report persisting to their best completion of difficult math questions.
[3]Percentages of students who persist to their best completion of difficult math questions (teacher reports).

Figure 11 shows that:

- The number of students who persist in working toward solutions for mathematics problems exceed provincial expectations.
- Students and teachers are in close agreement about the extent of student persistence.

Figure 12: Readiness-to-Learn Practices

Other indicators of students' readiness to learn include how they come prepared to engage in tasks and how they stay on-task. Student responses shown in Figure 12 indicate:

- Few students set goals prior to class or monitor their attention to the class activity.
- About half of the students commit to doing their best during the learning activity and consciously integrate new concepts w th their previous learning.

We also asked teachers about students' practices. Teachers think that students are more ready to learn than the students indicate. For instance, teachers believe that 75-85% of their students come to class committed to engage in the learning activity. This is well above student responses shown in Figure 12. Teachers may not realize the need to purposefully foster the development of these readiness-related practices.

Setting goals before class for what they will do and how well they will do

Grade 5	*Grade 8*	*Grade 11*
21%	11%	10%

Making a decision to pay attention and do the best they can during the class activity

Grade 5	*Grade 8*	*Grade 11*
63%	44%	49%

Checking to see if they are paying attention and meeting their goals

Grade 5	*Grade 8*	*Grade 11*
42%	27%	22%

Thinking hard about what they had previously learned to integrate new concepts

Grade 5	*Grade 8*	*Grade 11*
58%	45%	41%

Percentages are student-reported figures.

A significant factor contributing to the success students experience in school is the support they receive from their parents. Three aspects of parental support were investigated:

- attendance of parents at regular parent-teacher interviews or student-parent-teacher conferences;
- regular discussion with their children about academic progress; and,
- assistance given to help complete school assignments.

Fewer than expected parents attend school interviews, but they regularly talk with and help their children.

Figure 13: Parents' Involvement in Their Children's Education

Percentage of parents attending parent-teacher interviews or student-parent-teacher conferences

	Standard	Actual Reported[1]
Grade 5	84%	79%
Grade 8	87%	78%
Grade 11	61%	36%

Percentage of parents who regularly discuss academic progress with their children

	Standard	Actual Reported[2]
Grade 5	64%	60%
Grade 8	60%	62%
Grade 11	51%	73%

Percentage of parents who help their children with school assignments

	Standard	Actual Reported[2]
Grade 5	65%	78%
Grade 8	54%	74%
Grade 11	29%	53%

[1] *Actual Reported* figures are weighted averages of teacher responses. The following statements present these results in a different way.

- 58% of Grade 5 teachers report that **80-100%** of parents attended the last parent-teacher interview.
- 45% of Grade 8 teachers report that **80-100%** of parents attended the last parent-teacher interview.
- 8% of Grade 11 teachers report that **60-100%** of parents attended the last parent-teacher interview.

[2] as reported by students

Figure 13 shows that:

- The number of parents attending school interviews does not meet provincial expectations. This is particularly true for Grade 11.
- The number of parents regularly discussing academic progress with their children meets provincial expectations.
- At all grades, substantially more parents than expected help students with assignments.

Although the quality of discussion and help is unknown, students report that parents provide sufficient support and opportunities for learning.

III. Student Achievement

Introduction

In this chapter, achievements of Grade 5, 8, and 11 students are summarized. Results are provided for:

- overall achievement for performance-based tests;
- proficiencies in communicating mathematics understanding;
- comparisons of achievement for identical tasks between the grades; and,
- Grade 5 paper-and-pencil computation, multiple-choice, and problem-solving tasks.

Sample performance stations, problems, and questions are also included.

Determining Student Achievement

We established mathematics criteria for five achievement levels. *Level 5* achievement is highest and *Level 1* achievement is lowest. The tests gave students opportunity to attain any of these levels. Appendix F describes these five achievement levels in detail.

Teachers marked students' work. They examined the criteria, the tests, and student-work examples at each achievement level. For each student booklet, they assigned:

- an overall achievement level;
- a mathematics communication proficiency level; and,
- achievement levels for specific problems.

Appendix D describes the scoring procedure.

- *Level 5* achievement is the best and most insightful work of our most capable students.
- *Level 4* achievement indicates high proficiency and application skills.
- *Level 3* achievement is sound, adequate, and consistent.
- *Level 2* achievement represents only basic understanding of routine mathematics and lacks consistency.
- *Level 1* achievement is limited and poor.

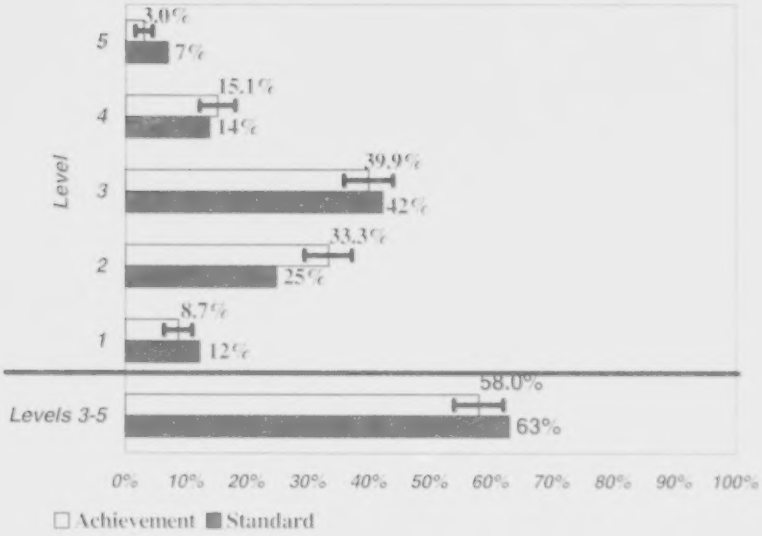
Understanding Student Achievement from the Graphs

Student achievement and standards are displayed as horizontal bars for each level. The bottom set of bars in the graph combine results and standards for *Levels 3* through *5*. These show the percentage of students attaining good mathematics achievement.

The results depend on whether the sample fairly represents the efforts and skills of Saskatchewan students. A sample of different students may yield different results. The '⊢⊣' at the end of each achievement bar indicates with 95% certainty that a similarly selected sample would have results within that range.

- If the '⊢⊣' overlaps the end of the standards bar, then achievement **met** the standard.
- If the entire '⊢⊣' extends beyond the end of the standards bar then achievement **exceeded** the standard.
- If the entire '⊢⊣' falls short of the standard's-bar end then achievement **has not met** the standard.

How to Read the Graph: Levels 5 Problem-Solving Test Results, Expected and Actual Outcomes



Please see **Appendix F** for the criteria describing student achievement at each of these five levels.

For this graph:

- the cumulative standard for *Levels 3-5* is 63% and the achievement is 58.0% ± 4.0% (indicated by the '⊢⊣' bar)
- achievement **met** the standard for *Levels 4* and *3*
- achievement **has not met** the standard for *Levels 5*, *1*, or cumulative *Levels 3-5*
- achievement **exceeded** the standard for *Level 2*

Note: In this case, falling short of the standard for *Level 1* achievement is good. Fewer students than expected performed at such a low level. However, exceeding expectations for *Level 2* achievement indicates more than expected students showed only basic mathematics understanding.

The graph shows that:

- Three percent of Grade 5 students attained *Level 5*, less than the 7% expected to do so. These students can:
  - insightfully create and/or use concrete manipulatives, original algorithms, or heuristics to find solutions to complex problems requiring consideration of several criteria
  - try a variety of strategies and persist to solve complex, non-routine problems
  - find several solutions to complex problems with a number of possible solutions
  - solve and explain extensions of problems in light of newly established relationships

- Fifteen percent of Grade 5 students attained *Level 4* meeting the expectation that 14% would do so. These students can:
  - use manipulatives in unique, innovative ways to solve problems
  - identify alternate strategies and use the "best" strategy for solving a problem
  - solve complex, multi-step problems appropriately addressing assumptions and all possible solutions
  - identify errors in logic, explain reasons leading to invalid conclusions, and where possible, correct the logic to arrive at valid conclusions

- Forty percent of Grade 5 students attained *Level 3* meeting the expectation that 42% would do so. These students can:
  - create simple manipulatives to solve a given problem
  - identify an additional strategy for solving a problem
  - solve multi-step problems
  - abstract beyond given information or materials to solve minor extensions of problems

- One-third of Grade 5 students attained *Level 2*. Only one-quarter were expected to do so. These students can:
  - use manipulatives without directions to solve simple problems
  - find more than one solution to a simple, multi-solution problem

- Fewer than expected Grade 5 students achieved *Level 1*. Nine percent of the students were restricted to:
  - using concrete materials (manipulatives) to perform simple operations
  - solving one-step operational problems

The criteria described for each achievement level apply to students in Grades 8 and 11, as well as those in Grade 5. The degree of difficulty and the classification of tasks as simple or complex would vary from Grade 5 through to Grade 11. Appendix F provides a more detailed list of the criteria for each achievement level.

Overall Achievement: Performance-Based Tests

The Nature of Performance-Based Tests

Performance-based tests at each of Grades 5, 8, and 11:

- included six stations which presented problem situations;
- provided materials (counters, blocks, dice, balances, rulers, shapes, etc.) to:
  - gather data to help solve the problem, or
  - manipulate to test strategies for solving the problem; and,
- allowed students to attain any one of the five achievement levels.

Students worked independently at each station. No direct observation of students occurred as they worked at the stations. Students' achievements were determined from their written responses.

Grade 5 Performance Station Tasks

The six performance stations at Grade 5 tested students related to:

- data management, graphing, and probability;
- multi-step translations and explanations of strategies;
- representation, equivalency, ordering, and addition of fractions;
- measurement, numbers and operations;
- area and perimeter relationships; and,
- communication of estimation strategies.

At the *Settling Cereal Problems* performance station, students used balances, bags of cereal, and cereal box-fronts to explore relationships between mass and capacity.

To complete this station's *Level 1* task, students either sequenced the cereals by the mass written on each box, or by the capacity of each box. In doing so, students showed they could order data by size (or quantity). They also showed the ability to follow explicit directions for limited step procedures.

Students experiencing little success beyond such introductory tasks at the stations were *Level 1* achievers.

Station 4 -- Settling Cereal Problems

Introduction:

Between mouthfuls of your favourite cereal, you see a small note on the cereal box. **This package is sold by mass, not capacity; some settling may have occurred during shipping and handling.** "What is all this about?" you wonder.

Materials:
1 balance scale and mass set
1 set of instructions for the use of the balance
3 sealed plastic bags - each with a different kind of cereal
3 laminated photocopies of the cereal box fronts

Procedure and Questions: *Level 1 Questions*

1. Look at the mass stated on each cereal box. Write the name of the cereal in the correct place in the table below.

Least Mass	Medium Mass	Greatest Mass

2. The capacity of a box is the amount of space inside the box. Now judge the capacity of each box (shown by the size of the photocopy). Write the name of the cereal in the correct place in the table below.

Least Capacity	Medium Capacity	Greatest Capacity

Question 3 at this station tested *Level 2* criteria. Students followed explicit directions for more complex procedures (use of the balance). They consistently made accurate measurements of the cereals' masses.

Level 2 achievers completed tasks involving the materials at the stations. They often failed to integrate prior knowledge and problem-solving strategies to perform higher-level tasks.

Students at *Level 3* solve multi-step problems. Here, they extract more than one piece of data from tables. They then must select and perform multiple operations on the data.

Level 3 represents good achievement. These students can integrate the activity at the stations with prior knowledge to solve minor extensions of the problem.

The *Level 4* criterion measured at this station is the ability to identify relationships between measured quantities. Students are expected to justify their conclusions. At this station, the absence of a clearly defined relationship between mass and capacity made this difficult.

At *Level 4*, students are beginning to explore the **why** of mathematics. They are often considering more abstract extensions of the problem or are communicating their reasoning more precisely.

Level 5 achievement is the best work of the most capable students in the class. Often, the nature of the problem extensions is beyond the student's grade level. This *Level 5* insightful work impresses the reader with the student's advanced-grade understanding.

Level 2 Question

3. For each bag of cereal, measure its mass. Record your results in the table below.

Name of Cereal	Mass (in grams) of 1 bag

Level 3 Question

4. Complete the table below by doing these steps.
   - Write the names of the cereals in the first column.
   - Look at the mass stated on the box of each cereal. Write these masses in the second column.
   - Now write the mass of each bag of cereal in the third column. These are the measurements you made and wrote in the table of question 3.
   - Look at the numbers you have just put into the table. For each cereal, calculate about how many of these bags you must empty into the cereal's box to equal the mass stated on the box. Put these answers in the last column of the table.

Name of Cereal	Mass stated on the box	Mass (in grams) of 1 bag	Number of Bags in the Box

Level 4 Question

5. Terry and Pat are arguing. Terry thinks that cereals with more mass take up more space (capacity). Pat thinks that cereals with more mass take up less space (capacity). From your work at this station, what do you think?

Level 5 Question

6. They are still arguing. Terry says steel is "heavier" than water. Pat disagrees. "I have a hard time lifting a large pail of water, but I can easily lift this steel pot" Pat says. "Yeah, but a steel volleyball pole is heavier than the pail of water" replies Terry.

   Can you help settle the argument? Explain how you might find out whether water or steel is "heavier".

At the *Settling Cereal Problems* station, Grade 5 students had to respond to a situation related to density; a topic they will not formally encounter for another four years. Successful *Level 5* responses explained the need to fix the capacity (or mass) of the substances to determine which is "heavier".

Pass the Pasta tested students' estimation and communication skills. Students explored alternate strategies to solve the problem. They then decided how to modify or replace those strategies in new situations that required estimation.

At this station, each question did not represent a distinct achievement level. Instead, scorers considered the full set of student responses to questions, and scored the quality of:

- creative and critical thinking; and,
- skill in communicating mathematics strategies and understanding.

Station 6 -- Pass the Pasta

Introduction:

Sometimes it takes too long or it is too hard to count a large number of objects. That's when good estimating skills are useful.

Materials:
a jar of macaroni
2 trays
a small vial (pill bottle)
a larger vial (pill bottle)
a jar of jelly beans

Procedure and Questions:

Estimate the number of macaroni in the jar. The trays and pill bottles might be useful. **You can take the macaroni out of the jar to help you estimate.** It would take too much time to count all of the pieces.

1. There are **about** _____ pieces of macaroni in the jar.
2. Describe what you did to estimate the number of macaroni pieces.
3. Explain another way you could use to estimate the number of pieces.
4. Many people are in the school gym for a Christmas program. Explain how you could estimate the number of people in the gym.
5. Jelly-beans are in a clear glass jar. **You must not open the jar.** **Explain** the best strategy to estimate the number of jelly-beans in the jar.

   Your estimate: _____ jelly-beans.

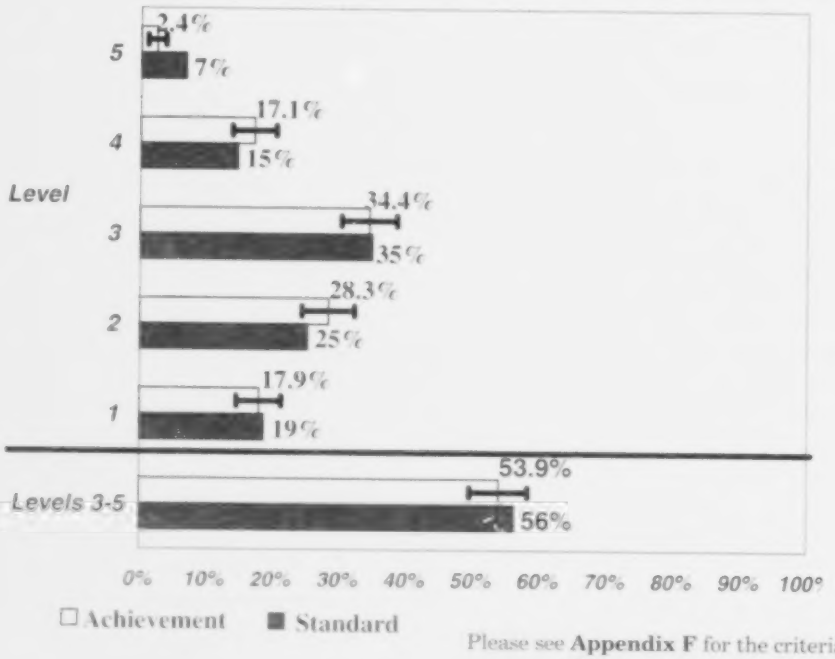
   This is what I did to estimate my answer. I ...

Grade 5 Overall Achievement Results

Grade 5 students' achievement met expectations for good mathematics proficiency. Fewer than expected attained the top level.

Overall achievement by Grade 5 students on the performance-based assessment met expectations for good mathematics proficiency (*Levels 3-5*). Figure 14 shows a close match between achievement results and standards.

Figure 14: Grade 5 Performance-Based Test Results, Expected and Actual Outcomes



Please see **Appendix F** for the criteria describing student achievement at each of these five levels.

Figure 14 shows that:

- About 54% of Grade 5 students showed good mathematics proficiency. This was in line with the 56% expected to do so.
- The number of students achieving *Levels 1* through *4* matched provincial expectations.
- Only one-third of the expected number of students attained *Level 5*.
- One in five students achieved *Levels 4* or *5*. These students demonstrate proficient and higher-level thinking. They can extend their knowledge and experiences at the stations to new and more complex situations.
- An additional one-third of Saskatchewan students (*Level 3*) showed sound and consistent application of mathematical skills. They integrated concepts and newly acquired knowledge to solve minor problem extensions.

More than 80% of Grade 5 students (*Levels 2-5*) have at least a basic understanding of mathematics. Almost one in five Grade 5 students showed limited achievement characteristic of *Level 1*. This number is consistent with provincial expectations and reflects the degree of difficulty of the performance tasks.

Students achieved higher scores in areas related to data management, bar graphs, and measurement. Students did not demonstrate an understanding of fractions. Less than 60% of Grade 5 students could use pattern blocks to represent and name fractions (numerator and denominator). Only one in three could use the blocks to apply principles of equivalency.

The use of pattern blocks and fraction strips provide concrete learning experiences to understand the difficult and abstract concepts of fractions.

Grade 8 and 11 Performance Station Tasks

Four of the six performance stations were common in the Grade 8 and Grade 11 performance-based tests. This provides insight into the development of mathematics skills and strategies from Grade 8 to Grade 11. These four stations involved:

- data management, graphing, and probability;
- combinations and counting principles;
- measurement, similarity, and ratios; and,
- functions, graphing, and equations.

The other two Grade 8 performance stations dealt with:

- the applications of fractions and percent; and,
- the use and explanations of strategies for multi-step translations.

The two additional Grade 11 performance stations related to:

- number patterns and factors; and,
- applications of measurement and functions.

One common performance station, *Caterers*, provided students with blocks to explore seating patterns. Students had to determine the relationship between the number of chairs that could be placed at a chain of tables.

To successfully fulfill *Level 1* criteria at this station students followed explicit directions and counted to determine the number of chairs at each grouping of three tables. Similar limited-step procedures and concrete thinking were required for most *Level 1* tasks. Students who achieved only these tasks were *Level 1* achievers.

To complete *Level 2* requirements of this station, students found the seating capacity at a chain of four and then five tables. To do so, they needed to identify the type of table arrangement that maximized seating capacity. They could use the available materials at the station or they could identify and use a simple number sequence.

Level 2 criteria for this task included:

- drawing simple conclusions directly from data;
- the use of manipulatives without directions to solve simple problems; and,
- the identification of basic number pattern relationships.

Students who did not progress substantially beyond completion of such questions were *Level 2* achievers.

Students showed *Level 3* proficiency at this station by graphically representing their data table. We expected them to use discrete points, not connected with a line, to show understanding of the situation. Students could also achieve *Level 3* if their work for questions 4 or 5, although not complete, showed they could solve minor extensions of the problem.

Station 6 -- Caterers

Introduction:

You have been hired as a caterer to prepare for a Thanksgiving dinner for many people. You experiment with possible table arrangements.

Materials:
5 yellow hexagonal pattern blocks
25 cubes

Procedure and Questions: ***Level 1 Question***

1. Each of the yellow hexagon blocks represents a table and each cube represents a chair. You are to determine the number of chairs that can be placed around various arrangements of tables. One chair can be placed along an open side of a table. You can use the blocks and cubes to figure out how many chairs are present in each of the following situations.

State the number of chairs that can be placed around each of the following three-table arrangements (one chair at each open side). Place your answers in the blanks below. The materials provided at this station might be helpful.

A chain of 3 tables:
allows for _____ chairs

A cluster of 3 tables:
allows for _____ chairs

Level 2 Question

2. Find out the maximum number of chairs that can be placed around four connecting tables and around five connecting tables. The materials provided at this station might be helpful. From the work on the previous page and your work with the materials, complete the chart below to show the most chairs that can be positioned around 1 table, 2 connecting tables, 3 connecting tables, and so on.

Number of Tables (x)	1	2	3	4	5
Number of Chairs (y)					

Level 3 Question

3. From the data table above, plot the **points** on the coordinate plane below.

After students generated and graphically represented the number pattern, they found a general rule to describe the relationship. *Level 4* attainment required students to state this general rule in a clear verbal or algebraic statement. The nature of *Level 4* questions at other stations varied. However, the ability to abstract as described by the criteria in Appendix F was characteristic of students achieving *Level 4*.

The question about silverware extended the problem's complexity. Students used a variety of strategies to solve this extension. Some found the relationship through an indirect substitution involving the number of chairs. Others found it by creating a new table of values. *Level 5* students communicated the relationship accurately and completely. Similar opportunity to show extensive, insightful, and thorough *Level 5* work was provided at each of the stations.

Level 4 Question

4. State the rule (equation) to show the relationship between the number of tables (x) and the number of chairs (y) for these table arrangements.

Level 5 Question

5. When the caterers are told how many connecting tables to position in a row, they set the silverware on the tables. The instructions for doing so are:

   - Each person is to have 3 pieces of silverware (a knife, a fork, a spoon).
   - Each table is to have 2 additional pieces of silverware (a sugar spoon and a butter knife).

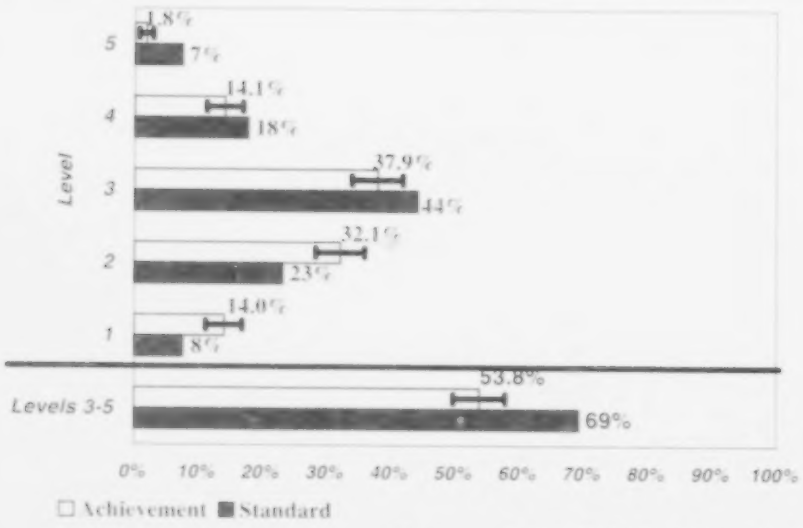
   State the rule (equation) to show the relationship between the number of tables (x) and the number of pieces of silverware (s).

Grade 8 Overall Achievement Results

Grade 8 students' achievement fell short of expectations for both good and excellent mathematics proficiency levels.

Overall achievement by Grade 8 students on the performance-based assessment did not meet the cumulative standard (*Level 3-5*) set for good mathematics proficiency.

Figure 15: Grade 8 Performance-Based Test Results, Expected and Actual Outcomes



Please see **Appendix F** for the criteria describing student achievement at each of these five levels.

Figure 15 shows that:

- While 69% of Grade 8 students were expected to achieve good mathematics proficiency (*Levels 3-5*), only 54% did so.
- The number achieving excellence was well below expectations. Less than 2% of the students explored and explained strategies to successfully solve complex problem extensions. Seven percent were expected to reach this highest achievement level.
- The standard of one-quarter of Grade 8 students achieving *Levels 4-5* was not met. Instead, 16% of the students considered several criteria, stated assumptions, and appropriately generalized or solved the abstract *Level 4* or *5* questions.
- Fourteen percent of Grade 8 students showed limited achievement below *Level 2*. This is almost twice the provincial expectations. These students did not sufficiently: follow explicit directions, perform simple operations, and draw simple conclusions.

The percentage of Grade 8 students achieving good mathematics proficiency was virtually identical to those doing so at Grade 5. However, the percentage of students expected to do so for Grade 8 (69%) was much higher than that expected for Grade 5 (56%).

Noticeable improvement was evident in students' conceptual understanding and application of fractions from Grade 5 to Grade 8. While Grade 5 students struggled to represent basic fractions, most Grade 8 students could:

- make groups based on given ratios;
- find a fraction of a fraction of a group;
- formulate and explain methods to fairly divide objects into groups;
- show versatility using common fraction and percentage formats; and,
- find scale factors of similar shapes and accurately state the ratios of their surface areas and volumes.

Grade 8 students are very good at representing data as bar graphs. Almost 85% could successfully generate data and then graphically represent it.

Grade 8 students had difficulties in:

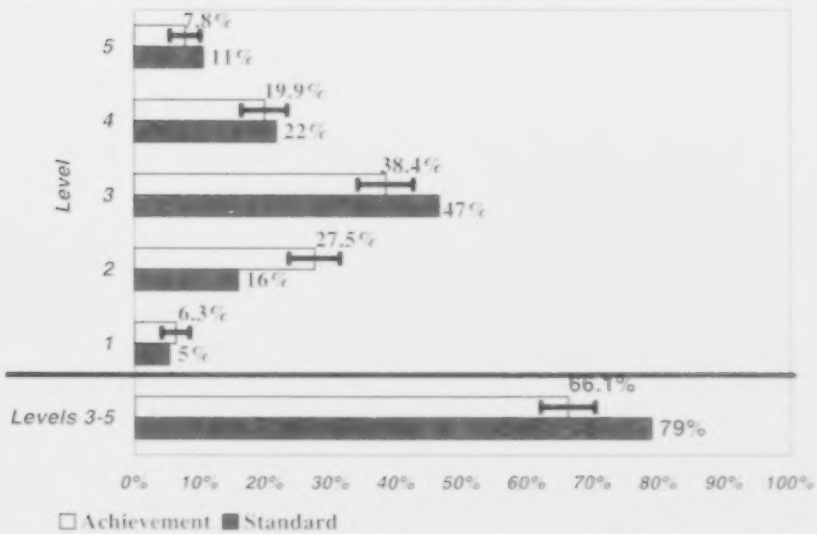
- plotting discrete points to represent a given situation;
- describing linear functions with an algebraic equation or clear verbal statement; and,
- applying geometry to solve situational problems.

Grade 11 students' achievement fell short of expectations for good mathematics proficiency. The number of students achieving the standard for excellence is near provincial expectations.

Grade 11 Overall Achievement Results

Four of the six performance stations, as described on page 23, were identical to those found in the Grade 8 test. When the stations were scored, more was expected of Grade 11 students.

Figure 16: Grade 11 Performance-Based Test Results, Expected and Actual Outcomes



Please see **Appendix F** for the criteria describing student achievement at each of these five levels.

Figure 16 shows that:

- Overall achievement by Grade 11 students did not meet provincial expectations for good mathematics proficiency (*Levels 3-5*). It was expected that about 24 students in a class of 30 students would show this proficiency. However, only 20 such students would be found in a typical Grade 11 classroom.

- More students than expected achieved *Level 2* and fewer than expected achieved *Level 3*.

- The percentages of Grade 11 students attaining *Levels 4* and 5 are close to expectation. These students are advancing beyond day-to-day mathematics applications to probe higher-order applications and reasoning.

- The percentage of students showing the limited achievement of *Level 1* matched the expected 5% figure.

- Provincial expectations for good mathematics proficiency was highest for Grade 11. Seventy-nine percent of Grade 11 students were expected to achieve *Levels 3-5*. Such achievement was expected of 69% of Grade 8 students and 56% of Grade 5 students.

In a class of 30 students, about eight would have performed at *Level 2*. These students show a basic understanding of routine mathematics situations. To achieve *Level 3*, they need to solve minor problem extensions, increase their attention to detail, and more effectively communicate their understanding.

Grade 11 students achieved well in problem situations involving data management, probability, combinations, measurement, and similarity. They had difficulties deriving algebraic equations, identifying assumptions, and using explanations to describe relationships in the data. Many students did not adequately understand the graphs they used. The following two examples show many students do not consider the real-life context represented by numbers.

- We asked them to plot points showing the number of chairs around different numbers of tables. Forty percent of the students connected the points with a line (allowing for the possibility of fractional numbers of tables and chairs).

- In another problem, we gave a graph showing the relationship between the depth of water in a container and the volume of water added. Few students could draw the shape of the container represented by this graph.

Communicating Mathematics Understanding

Thought is how people bring order and meaning to facts and experience, and language is used to express thought. Students use thought and language to ask questions, discuss ideas, explore alternate strategies, and justify conclusions. When students are asked to document their thinking in journals or reports, they must clarify their thinking.

Mathematics educators verify the importance of communication in mathematics.

> In grades 5-8, the study of mathematics should include opportunities to communicate so students can:
>
> - model situations using oral, written, concrete, pictorial, graphical, and algebraic methods;
> - reflect on and clarify their own thinking;
> - develop common understandings of mathematical ideas, including the role of definitions;
> - use the skills of reading, listening, and viewing to interpret and evaluate mathematical ideas;
> - discuss mathematical ideas and make conjectures and convincing arguments; and,
> - appreciate the value of mathematical notation.
>
> In grades 9-12, the mathematics curriculum should include the continued development of language and symbolism so that all students can:
>
> - reflect upon and clarify their thinking;
> - formulate mathematical definitions and express generalizations discovered through investigations;
> - express mathematical ideas orally and in writing;
> - read written presentations of mathematics;
> - ask clarifying and extending questions; and,
> - appreciate the economy, power, and elegance of mathematical notation (National Council of Teachers of Mathematics, 1989).

Factors Affecting the Assessment of Communication in Mathematics

All student achievement was gauged from written responses to questions. There was no group work and no direct observation of students' attempts to communicate orally.

Standard-setting panelists identified two other possible difficulties in assessing communications achievement.

- Although we asked students to show their work in the opening directions for the assessment, we did not remind them to do so within each question.

- Students who lacked sufficient numeracy and creative and critical thinking skills might have little to communicate.

Judging Written Communication in Mathematics

Three categories were used to describe students' written communication in mathematics: *Beginning Communication*, *Adequate Communication*, and *Proficient Communication*. Scorers examined criteria and grade-appropriate student examples when judging communication proficiency.

Students with *Beginning Communication* in mathematics:

- show little work;
- offer little explanation in their solutions; and,
- give explanations that are difficult to follow.

Students exhibiting *Adequate Communication* in mathematics:

- follow directions;
- provide common-language explanations (may lack detail and require some interpretation by the reader);
- use rudimentary diagrams or illustrations with explanations; and,
- respond with sufficiently clear solutions to problems.

Students with *Proficient Communication* in mathematics show:

- elements of precision, clarity, and elaboration;
- use mathematical terminology; and,
- use diagrams, graphs, or examples to support their explanations.

Examples of proficiencies in students' mathematics communications

We asked Grade 5 and 8 students to describe their solutions to the following. (These are actual student responses, and so errors are those of the students.)

2. We can move objects from one location to another using *translations* (slides), *rotations* (turns), and/or *reflections* (flips). Describe the steps needed to move a triangle from triangle position 1 to triangle position 2 as shown on the square below. The plastic overlay triangle at this station may be helpful.

Write the description of the steps you used in as much detail as possible.

Responses that exemplify:

Proficient Communication:

- You flip the triangle keeping point B on B. Rotate until corner A is on C. (clear; references to points)
- I held my finger on angle B all the time. I then fliped the trainangle once to get it into position 1a, then I slide it down into position 2. (Although this student refers to a slide that should be a rotation, he/she drew a triangle 1a reflected along BE with arrows showing movements illustrating interplay between explanations and diagrams.)

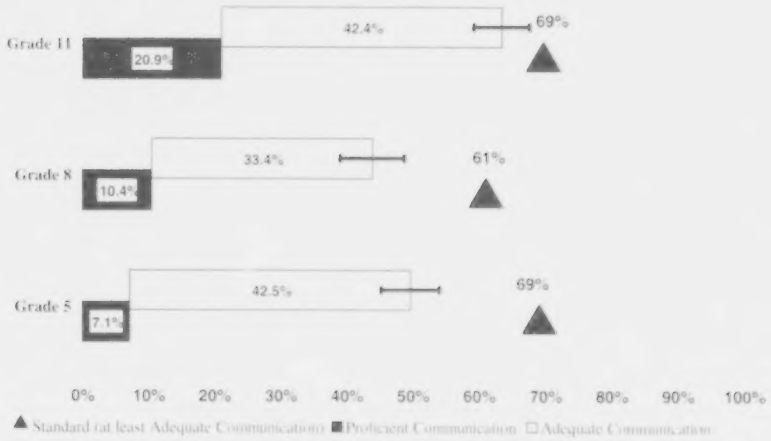
Adequate Communication:

- From position 1 to 2 I needed to rotate it and flip it.

Beginning Communication:

- you would flip it

Figure 17: Grade 5, 8, and 11 Proficiencies in Communicating Mathematics Understanding, Expected and Actual Outcomes



In all grades assessed, the numbers achieving *Adequate Communications* and *Proficient Communications* did not meet provincial expectations.

Figure 17 shows that:

- In all grades assessed, actual student achievement fell short of expectations.
- Of the three grades, students in Grade 11 most closely approached provincial expectations for adequate or proficient communication skills. Sixty-three percent of them demonstrated such skills; 69% were expected to do so. Grade 5 and Grade 8 students showed larger gaps between actual and expected proficiency in communication. For Grade 5, half of the students showed adequate or proficient skills, short of the expectation that 69% would do so. Only 44% of Grade 8 students showed such proficiency, while 61% were expected to do so.
- One in five Grade 11 students demonstrated *Proficient Communication* skills, meeting the 18% standard. Those students expressed answers and explanations with precision and clarity, referencing appropriate mathematical terminology, symbolism, and examples.
- About 7% of Grade 5 students and 10% of Grade 8 students demonstrated *Proficient Communication* skills in mathematics. These were below the provincial expectations of 18% for Grade 5 and 14% for Grade 8.

Standard-setters expect results to improve as teachers integrate into daily classroom activity the Core Curriculum recommendations for developing student communication skills. These include stressing process as well as product, providing opportunities to solve problems and communicate in small groups, and encouraging effective journal writing in mathematics.

Comparing Achievements Among the Grades for Common Tasks

To examine development of mathematical and critical thinking skills from Grade 5 to Grade 8 to Grade 11, students completed one common performance station. Teachers scored the student work using identical criteria. That is, Grade 5 student work was judged as stringently as Grade 8 and 11 student work.

We asked students to do a number of tasks at the *Win or Lose* station:

1. roll a pair of eight-sided dice 30 times, sum each pair, and place a tally mark in a chart representing sums from 1 to 16;
2. cite the sum (sums) that occurred most often;
3. graphically represent the data in their chart;
4. predict the most frequent sum if 1000 rolls were made and justify this prediction (extension from experimental probability to theoretical probability); and,
5. design a new pair of dice that satisfy several criteria (minimum sum of zero, maximum sum of 20, no possible sum of 5, all other whole number sums possible).

A separate set of standards was set for each of Grades 5, 8, and 11 related to this one performance station. These standards refer to this one common set of tasks and are distinct from those describing expectations for students' overall achievement for the tests.

Figure 18: Grade 5, 8, and 11 Comparisons, Expected and Actual Outcomes for the Win or Lose Station

	Grade 5		Grade 8		Grade 11	
	Expected Outcome	***Actual Outcome***	***Expected Outcome***	***Actual Outcome***	***Expected Outcome***	***Actual Outcome***
Level 5	2%	2%● (± 1.3)	8%	14%▲ (± 2.8)	25%	28%● (± 5.6)
Levels 4-5	4%	12%▲ (± 2.9)	23%	31%▲ (± 3.8)	50%	54%● (± 6.2)
Levels 3-5	37%	58%▲ (± 4.5)	75%	84%▲ (± 3.0)	94%	95%● (± 2.6)
Levels 2-5	77%	82%▲ (± 3.5)	96%	92%▼ (± 2.2)	99%	99%● (± 1.1)

Notes:
⇒ The bracketed numbers in the *Actual Outcome* columns show the percentage margin of sampling error.
▲ indicates actual outcomes exceeded expectations for the specified level or range of levels
● indicates actual outcomes met expectations for the specified level or range of levels
▼ indicates actual outcomes fell short of expectations for the specified level or range of levels

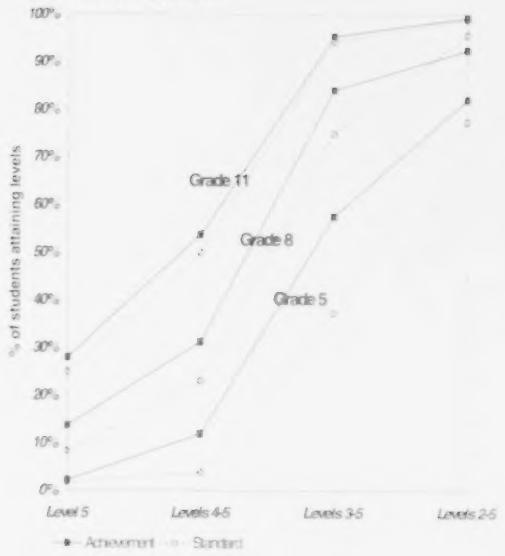
Figure 18 shows that:

- As expected, Grade 11 achievement was superior to Grade 8 achievement which was superior to Grade 5 achievement.

- The gap between achievements of the different grades is particularly large at *Levels 4 and 5* when the students had to think more critically.

- There are some insightful elementary students who think critically. Two percent of Grade 5 students succeeded in doing what 72% of Grade 11 and 86% of Grade 8 students could not do: design the new dice to attain *Level 5* achievement.

Figure 19: Grade 5, 8, and 11 Graph of Expected and Actual Outcomes for the Win or Lose Station



Unlike results for overall student achievement on the performance-based tests, students' achievements for this one performance station compared favourably with the station-specific standards. Specifically, Figure 19 shows that:

- Grade 11 students performed as well as expected at this station.
- For Grades 5 and 8, achievement exceeded expectations for this station. Two exceptions are noted. Fewer Grade 8 students than expected attained *Level 2*. The percentage of Grade 5 students attaining *Level 5* matched expectations.
- As expected, achievement improves at the higher grades.
- The increase in achievement is paralleled by an increase in standards.

Standard-setting panelists were impressed with the difficulty of the tasks for Grade 5 and Grade 8 students. They were pleased with the skills of these students in representing data with graphs and in thinking critically about combinations and probability.

Two other common performance stations were analytically scored to observe trends in achievement between Grade 8 and Grade 11 students. Formal standards were not set for achievement at each of these individual stations.

Figure 20: Grade 8 and 11 Comparisons, Actual Outcomes for the Sim Solids and Caterers Performance Stations

	Sim Solids Station		Caterers Station	
	Grade 8	*Grade 11*	*Grade 8*	*Grade 11*
Level 5	2%	14%	1%	9%
Levels 4-5	18%	74%	8%	21%
Levels 3-5	48%	88%	35%	62%
Levels 2-5	86%	93%	78%	96%

Figure 20 and related findings indicate:

- Grade 11 achievement exceeds Grade 8 achievement across all combined levels.
- Grade 8 and 11 students can measure lengths and apply given formulas.
- Many Grade 8 students had difficulty plotting points from a table of values (27% made bar graphs). Grade 11 students did not have this difficulty.
- 17% of Grade 8 and 41% of Grade 11 students joined the points inappropriately with a line. This may represent a lack of understanding of what this graph represents. A fractional number of tables and chairs should not be represented.
- Very few Grade 8 students and relatively few Grade 11 students could express the relationship between two variables using a clear verbal explanation or an algebraic equation (*Caterers: Levels 4-5*).

At the Sim Solids station, tasks included:

1. measuring the dimensions of three similar rectangular solids;
2. calculating the volume and surface areas of these solids (given the formulas);
3. calculating the ratios of their lengths, surface areas and volumes;
4. calculating and justifying effects on volume of changing linear dimensions; and,
5. exploring the relationship between surface areas and volumes when changing dimensions and its application in packaging.

At the Caterers station, the tasks included:

1. determining the number of chairs around given table arrangements;
2. creating a table of values by extrapolating the number of chairs for different numbers of tables;
3. plotting points from the table of values;
4. finding a clear-language or algebraic rule to describe the relationship between the number of chairs and the number of tables; and,
5. finding a clear-language or algebraic rule between a third variable (silverware) and the number of tables.

Note: The number in front of each task is the Level awarded for successful completion of the task.

Grade 5 Paper-and-Pencil Test Results

Over 600 Grade 5 students wrote the paper-and-pencil tests. They completed:

- a student questionnaire;
- an 8-item computation test;
- a 40-item multiple-choice test; and,
- a test with six extended problems.

Students finished these over a two-day period. The first day, they completed the questionnaire, computations, and multiple-choice items. The second day, they wrote the problem-solving test.

Computation Skills

Students performed eight computations without a calculator. They did four computations involving whole numbers and four involving decimal numbers. The computations required students to add, subtract, multiply, and divide. Achievement standards were not set for these computation skills. Without provincial expectations, readers must draw their own conclusions about the adequacy of Grade 5 students' computation skills. Appendix A shows that there has been no significant change in these skills from 1995 to 1997.

Figure 21: Grade 5 Computation Skill Results by Question Type

	Whole Numbers	Decimal Numbers
Addition	92.7%	68.3%
Subtraction	69.4%	40.2%
Multiplication	63.1%	61.9%
Division	56.1%	49.2%

Note: Percentages show the proportion of students correctly answering each type of question.

Figure 21 shows that:

- Students experienced more success performing computations with whole numbers than with decimal numbers.
- Students performed best in addition and poorest in division. Subtraction proficiency was substantially lower than proficiency in addition.

Figure 22 indicates Grade 5 students' overall computation proficiency. It shows:

- About one in ten Grade 5 students scored perfectly on the computations test.
- Twice that number had fewer than four computations correct.

The average score was 5.07 of the 8 questions completed correctly.

Figure 22: Grade 5 Computation Skills Frequency Distribution

8 correct	9.3%
6-7 correct	36.3%
4-5 correct	32.8%
2-3 correct	16.9%
0-1 correct	4.7%

Note: Percentages show the proportion of students achieving the specified number of correct responses.

Calculator Use and Computation Skills

Results show that computational skills among Grade 5 students are not affected by regular use of calculators. Students stated on the questionnaire whether they used calculators for mathematics at school or at home.

Grade 5 students' computation skills have not deteriorated as a result of using calculators.

Almost 200 students (35%) said they never used calculators. Results for these students were:

- an average score of 5.01 (out of 8);
- 7.5% of these students performed all the computations correctly; and,
- 79% of them correctly completed at least half of the computations.

Results were virtually identical for the 376 students (65%) who said they used calculators for mathematics. Their results were:

- an average score of 5.10 (out of 8);
- 10% of them performed all the computations correctly; and,
- 78% of them correctly completed at least half of the computations.

Mathematics Content Skills

Grade 5 students wrote a 40-question multiple-choice test. The test measured students' understanding of mathematics concepts, procedures, and relationships. Contextual clues in the form of diagrams and situations were provided for several questions. Sample questions are shown below.

5. Chris buys socks for $3.97, a hat for $12.45, and a water bottle for $6.25. She gives a $20 bill and a $10 bill to the cashier. How much change does she get back? (No tax is charged.)

a. $2.67
b. $7.33
c. $8.33
d. $8.43

65% of Grade 5 students correctly answered this question.

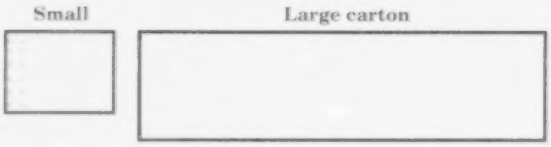
14. Pictures of 4 fractions are drawn below.

Which of the following has the fractions going from largest to smallest?

a. $\frac{5}{7}, \frac{5}{6}, \frac{1}{2}, \frac{1}{8}$
b. $\frac{5}{6}, \frac{5}{7}, \frac{1}{2}, \frac{1}{8}$
c. $\frac{1}{8}, \frac{5}{7}, \frac{5}{6}, \frac{1}{2}$
d. $\frac{5}{7}, \frac{5}{6}, \frac{1}{8}, \frac{1}{2}$

18% of Grade 5 students correctly answered this question.

19. Pat has a job on the farm. She puts eggs in cartons. The small carton is ¼ full.



She will fill the small carton and the large carton. About how many eggs will be in the large carton?

a. 50
b. 150
c. 250
d. 350

37% of Grade 5 students correctly answered this question.

32. Marvie found an ugly beetle bug. How long do you think his bug is?

a. 23 mm
b. 23 cm
c. 23 m
d. 23 km

71% of Grade 5 students correctly answered this question.

Figure 23: Grade 5 Multiple-Choice Test Results

Strand	*Avg. Score*	*Top 10%*	*Top 25%*	*Top 50%*
Overall	52%	73%	63%	53%
Whole Numbers	62%	92%	75%	67%
Fractions & Decimals	35%	67%	44%	33%
Geometry	41%	67%	50%	33%
Measurement	56%	88%	75%	63%
Data Management	68%	100%	80%	80%

Note: The last three columns indicate the minimum percentages that students in the *Top 10%*, *Top 25%* and *Top 50%* categories had correct in each strand. For example, a student with at least 73% of the questions correct would be in the *Top 10%* of performers. In this assessment, students had to score at least 63% correct to be in the *Top 25%* and at least 53% correct to reach the *Top 50%* of performers.

Figure 23 shows that:

- Students had difficulty with this test. The average score was 52%.
- A student needed only 73% to rank in the *Top 10%*.
- Students scored low in all strand areas except in data management.
- *Fractions & Decimals* (average of 35%) and *Geometry* (average of 41%) strands were areas of lowest achievement. Only 20% of Grade 5 students answered at least half the *Fraction & Decimal* questions correctly.
- Over 20% of the students had all the data management questions correct. This number dropped to under 4% correctly answering all the whole number application questions, and 2.5% answering all the measurement questions correctly. Fewer than 1% of the students answered either all the fractions or all the geometry questions correctly.

Problem-Solving Skills

Grade 5 students also completed six extended problems. These were similar in structure to the tasks in the performance-based test, except students did not have hands-on manipulatives.

The six problems involved:

- data management - retrieving information from tables, representing data using graphs, making assumptions and generalizations from data, sampling considerations;
- numbers and operations - performing calculations with money, satisfying criteria involving the number and value of coins;
- geometry - exploring the relationship between the perimeter and the area of a rectangle;
- communications in geometry & measurement - an open-writing exercise about properties of squares and rectangles;
- fractions - exploring representation of fractions, equivalent fractions, ordering fractions, and adding fractions; and,
- data management & numbers and operations - making menu selections to satisfy a variety of conditions.

Be a Sport

In the grade 5 classes of a Moose Jaw school, there are 29 males and 32 females. These classes were asked which sport they like to watch best on TV. A number of males were away at a hockey tournament. Only 10 males and 30 females were present. This table shows the survey results.

Sport	Males	Females	Total
Tennis	1	7	8
Basketball	4	10	14
Gymnastics	1	2	3
Football	1	2	3
Skating	1	2	3
Baseball	0	1	1
Hockey	1	4	5
Golf	0	1	1
Soccer	1	1	2

a) How many grade 5 females in this school like to watch hockey on TV the best?

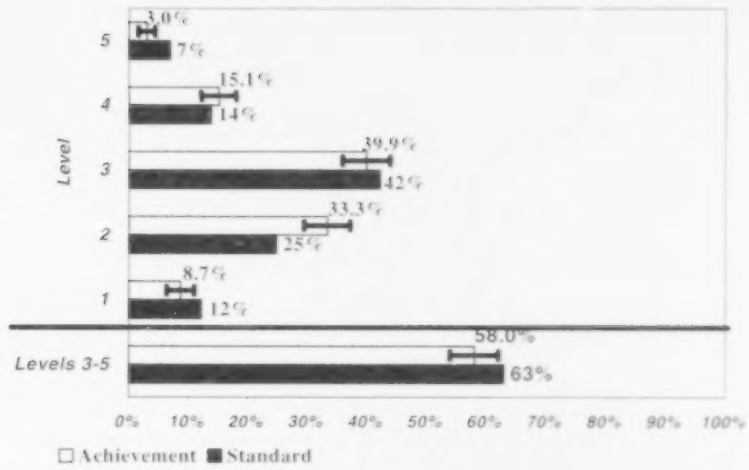
b) In this school, how many more females than males like to watch basketball on TV the best?

c) Draw a bar graph or circle graph to show the sports that grade 5 females in the above school like to watch. Use the grid paper or circle provided.

d) Chris was surprised at the results. "Females in Saskatchewan like watching basketball on TV the best," she told her friend. Would you tell your friend the same thing? Explain.

e) Can you make a statement about the sports the grade 5 males in the school like to watch on TV the best? Explain.

Figure 24: Grade 5 Problem-Solving Test Results, Expected and Actual Outcomes



Grade 5 students' achievement in solving problems was close to expectations.

Efforts are required to double the number of *Level 5*-performing students to approach the 7% standard.

Please see **Appendix F** for the criteria describing student achievement at each of these five levels.

Figure 24 shows that:

- Overall achievement by Grade 5 students in solving these extended problems falls just short of the cumulative standard (*Levels 3-5*) set for good mathematics proficiency. About 58% showed such proficiency, short of the expected 63%.

- The number of students attaining *Level 3* and *Level 4* met provincial expectations.

- Fewer students than expected remained at *Level 1*. Still, 42% of Grade 5 students are currently below the *good proficiency* status of *Level 3*.

- Most of the shortfall occurs at *Level 5* achievement. Fewer than half the number of students expected to show the insightful characteristics of *Level 5* did so.

Student difficulties with Level 5 tasks included:

- making appropriate generalizations and identifying sample biases when analyzing data;
- considering several criteria and multiple solutions when solving problems;
- verbalizing and applying geometry concepts including perimeter and area relationships; and,
- showing conceptual understanding of operations with fractions.

The overall achievement and standards were similar to those of the Grade 5 performance-based test. This was particularly true for *Levels 4* and *5*. Achievement results for the written test were slightly better at *Levels 1-3* than for the performance-based test.

IV. Student Achievement, Attitudes, and Practices

This chapter examines:

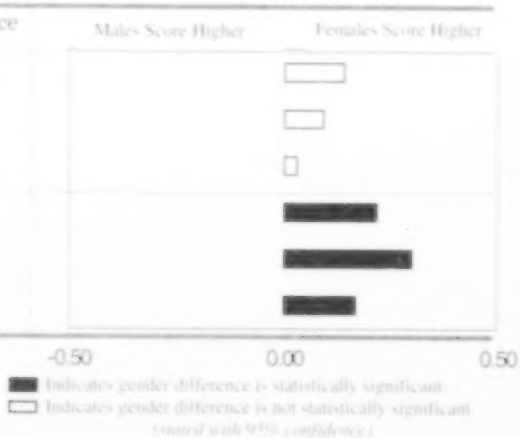
- gender differences in student achievement; and,
- students' attitudes and confidence related to mathematics.

Gender Differences in Achievement

Females achieved higher scores than males in most areas of the assessment.
This is particularly true for written communications in mathematics.

Figure 25: Average Scores of Females and Males, 1997 Provincial Mathematics Performance-Based Tests

	Females	Males	Difference
Gr 5 Overall	2.65	2.51	0.14
Gr 8 Overall	2.64	2.55	0.09
Gr 11 Overall	2.97	2.94	0.03
Gr 5 Communications	2.68	2.46	0.22
Gr 8 Communications	2.70	2.40	0.30
Gr 11 Communications	2.93	2.76	0.17



Scores are the average attained on the *Level 1* to *5* scale.

Figure 25 shows that:

- Females outscore males in all three grades assessed.
- Females' proficiencies are especially higher than males' for written communications in mathematics. Generally, the organization, explanation, and presentation of work by females is significantly better. The achievement gap between the genders is greatest at Grade 8 but has narrowed by Grade 11.

Figure 26: Attainment of Good Mathematics Proficiency Levels, 1997 Provincial Performance-Based Tests

	***Level 3-5* Overall Achievement**			***Adequate* or *Proficient* Communication**		
	Females	***Males***	***Difference***	***Females***	***Males***	***Difference***
Grade 5	55.6%	52.1%	3.5%	57.1%	42.5%	14.6%
Grade 8	57.1%	51.8%	5.3%	53.8%	34.5%	19.3%
Grade 11	67.3%	65.0%	2.3%	68.4%	58.2%	10.2%
	None of these differences is statistically significant (stated with 95% confidence).			**All** of these differences are statistically significant (stated with 95% confidence).		

Figure 26 shows that:

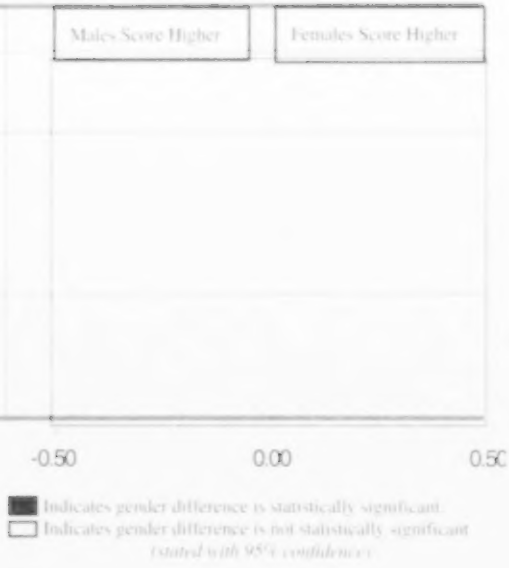
- The numbers of females attaining good mathematics proficiency exceed those of males, but these differences are not statistically significant.
- Differences in communication skills are statistically significant at all grades assessed. This is especially true in Grade 8. Only one-third of Grade 8 males had *Adequate* or *Proficient* communication achievement.

When some performance stations were analytically scored and communications was less of a consideration, the differences were less dramatic (see Figure 27).

Figure 27: Average Scores of Females and Males, Individual Performance Stations

	Females	Males	Difference
Grade 5 Win or Lose	2.51	2.39	0.12
Grade 5 Fractions I	1.98	1.81	0.17
Grade 8 Win or Lose	3.19	3.16	0.03
Grade 8 Fractions II	2.70	2.87	-0.17
Grade 8 Sim Solids	2.52	2.45	0.07
Grade 8 Caterers	2.18	2.15	0.03
Grade 11 Win or Lose	3.67	3.87	-0.20
Grade 11 Sim Solids	3.65	3.62	0.03
Grade 11 Caterers	2.86	2.90	-0.04

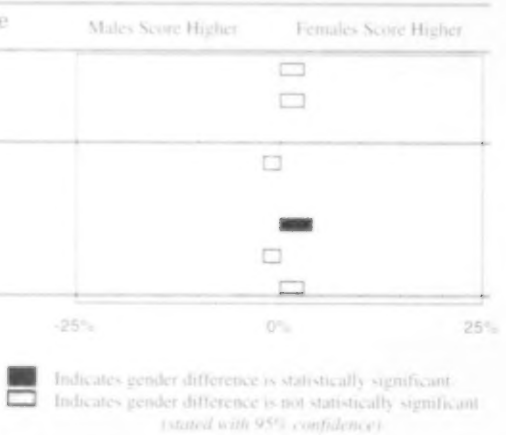
Scores are the averages attained at each station on the *Level 1* to 5 scale.



Were gender differences in achievement evident for the Grade 5 paper-and-pencil tests? A summary of findings is shown below.

Figure 28: Grade 5 Paper-and-Pencil Average Test Scores, Females and Males

	Females	Males	Difference
Problem-Solving	2.78	2.63	0.15
Computations	65%	62%	3%
Multiple-choice (overall)	52%	52%	0%
- whole number strand	61%	63%	-2%
- fractions strand	35%	35%	0%
- geometry strand	43%	39%	4%
- measurement strand	55%	57%	-2%
- data management strand	69%	66%	3%



Notes: Problem-solving average scores use a *Level 1* to *5* scale. Other averages are percentage correct on tests.

Figure 28 shows that:

- Grade 5 females and males achieved similar results in the paper-and-pencil tests.
- The only statistically significant difference between the genders was in geometry. Here, the average scores of females exceeded the average score of males.

Mathematics-Related Attitudes and Practices

Usefulness of Mathematics

Most students believe their classroom mathematics is useful.

Do students find the mathematics content and thinking processes learned in class useful in:

- everyday life;
- other subjects studied at school;
- preparation for further schooling; and,
- securing a good job?

We wanted students to select responses related specifically to the mathematics they were learning, not just mathematics in general. Also, we asked about both mathematics content and processes.

Figure 29: Usefulness of Mathematics Content and Processes, Student Responses

	Content			Processes		
	Grade 5	*Grade 8*	*Grade 11*	*Grade 5*	*Grade 8*	*Grade 11*
everyday life	66%	58%	34%	69%	62%	48%
other subjects	51%	46%	46%	53%	51%	52%
future schooling	67%	70%	69%	68%	71%	70%
secure a good job	71%	66%	55%	68%	61%	54%
not useful	6%	10%	19%	5%	9%	15%

Figure 29 shows that:

- Mathematics is useful in preparation for future schooling according to 70% of students across Grades 5, 8, and 11. Fewer students believe mathematics is helpful in other subject areas or in everyday life.

- The perceived utility of mathematics decreases at the higher grades. The percent of students stating no use for their classroom mathematics triples from Grade 5 to Grade 11. Two-thirds of Grade 5 students find the content in their mathematics classroom useful to everyday life, but this sentiment is shared by only one-third of Grade 11 students.

- Less than half the Grade 11 students find day-to-day application for strategies and thought processes developed in their mathematics classroom. Students did not discern much difference in usefulness between mathematics processes and content.

Students' Attitudes in Mathematics

Most Grade 5 students like mathematics and are confident in their abilities.
Such numbers are lower in Grades 8 and 11.

We asked students to strongly agree, agree, disagree, or strongly disagree to the following statements:

- *I like mathematics.*
- *I feel confident when I do mathematics questions.*

Figure 30: Students' Attitudes in Mathematics

	Like Mathematics[1]	Confidence[2]	Confidence (like mathematics)[3]	No Confidence (like mathematics)[4]
Grade 5	78%	81%	27% (92%)	4% (35%)
Grade 8	56%	68%	14% (89%)	9% (7%)
Grade 11	57%	55%	13% (94%)	12% (2%)

[1]Percentage of students who strongly agree or agree to liking mathematics.
[2]Percentage of students who strongly agree or agree to being confident when doing mathematics questions.
[3]Numbers in front of the brackets are the percentages of students who **strongly agree** they are confident when doing mathematics. The numbers in the brackets are the percentages within this group who like mathematics.
[4]Numbers in front of the brackets are the percentages of students who **strongly disagree** they are confident when doing mathematics. The numbers in the brackets are the percentages within this group who like mathematics.

Figure 30 shows that:

- Seventy-eight percent of Grade 5 students like mathematics. Those liking mathematics declines to 56% in Grade 8 and 57% in Grade 11.
- Students' confidence in their mathematics abilities steadily decreases as they advance to the higher grades. The 81% who are mathematically confident in Grade 5 outnumber the 68% in Grade 8, and the 55% in Grade 11.
- Those reporting strong confidence in Grade 8 and 11 is half the 27% doing so in Grade 5.
- The size of the least confident group increases from 4% of Grade 5 students to 9% of Grade 8 students, and then to 12% of Grade 11 students.
- Not surprisingly, there is a strong relationship between how well students like mathematics and the confidence they have in their mathematics abilities.

Other findings were:

- Grade 5 females like mathematics as much as males. However, by Grade 8 only half the females like mathematics compared to two-thirds of the males. These proportions remain the same for Grade 11.
- Males and females are equally confident in Grade 5. However, more males than females retain this confidence throughout the higher grades. By Grade 11, about two of three males are still confident in their mathematics abilities. Less than half the females still have this confidence.

Relating Attitudes and Achievement

Attitudes students have toward mathematics can affect how well they do in mathematics. Also, how well students do in mathematics can affect their attitudes toward mathematics. These relationships are explored in this section.

Students who like mathematics achieved higher scores than those who do not.
A strong relationship exists between achievement and how confident students are when doing mathematics.

Figure 31: Average Scores of Students Related to Their Attitudes

	Students Who Like Mathematics		Students Confident in Their Mathematics Abilities	
	Average Score	*Advantage*	*Average Score*	*Advantage*
Grade 5	2.68	0.13	2.71	0.37▲
Grade 8	2.71	0.28▲	2.72	0.39▲
Grade 11	3.17	0.51▲	3.28	0.68▲

Notes: Scores are the average attained on the *Level 1* to *5* scale.
▲indicates this advantage is significant (stated with 95% confidence).

Figure 31 shows that:

- Students who like mathematics scored higher, on average, than those who do not. This advantage increases at the higher grades and is significant in Grades 8 and 11.

- An even stronger relationship is evident between achievement and students' confidence in their mathematics abilities. Confident students averaged higher scores at all grades assessed. In Grade 11, they scored 0.68 levels higher than those who lack confidence.

The achievement of the group that agrees strongly to liking mathematics was compared to the group that disagrees strongly to liking mathematics. Similarly, those who strongly agree to being confident when doing mathematics were compared to those who strongly disagree having such confidence. At each grade, the achievement gap between these polarized groups doubles the advantages listed in Figure 31.

Figure 32: Achievement by Attitude and Gender

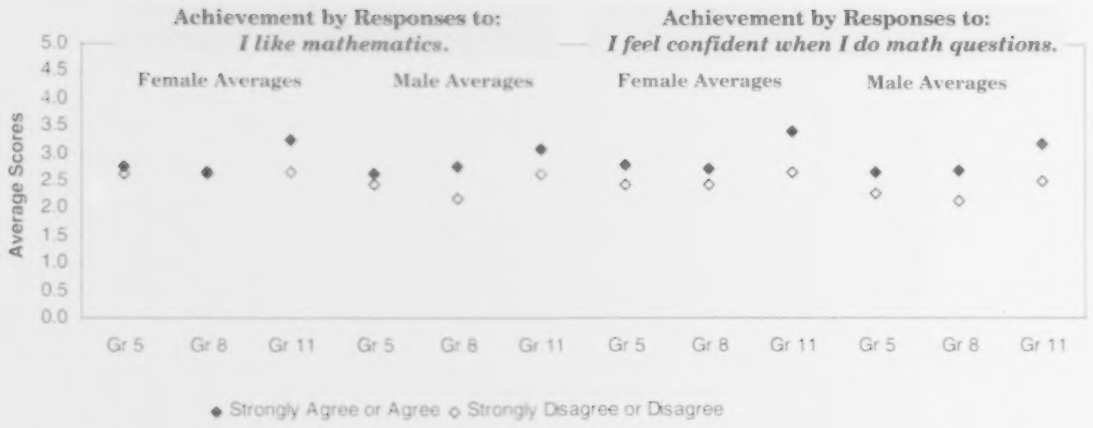


Figure 32 shows how achievement scores vary with attitude and gender. A short line between symbols indicates that achievement was similar between groups. Longer lines between the symbols indicate that achievement does vary more with attitudes. The figure shows that:

- For both Grade 5 females and males, achievement does not differ between groups that like or don't like mathematics. This is also true of Grade 8 females.

- For Grade 8 females, there is no discernible difference in achievement between those who like mathematics and those who do not. However, males in Grade 8 who like mathematics scored significantly higher than those who do not.

- For both Grade 11 females and males, there is a difference in achievement based on whether or not they like mathematics.

- Similar but amplified patterns occur across the grades when viewing achievement of students who are confident when doing mathematics questions and students who are not.

V. Conclusions and Next Steps

The 1997 Provincial Mathematics Learning Assessment affirms the findings of the 1995 Assessment: students' achievement in mathematics falls short of provincial expectations. With few exceptions, Grade 5, 8, and 11 students do not meet the standards for good and top level mathematics proficiencies. Specifically, students do not:

- consistently show a conceptual understanding of numbers, their representation, operations, and application to real-life situations;
- adequately communicate their mathematics understanding; and,
- sufficiently apply basic skills to solve extensions to problems.

Significant challenges lie ahead to facilitate student understanding and application of mathematics to meet provincial expectations for achievement. Responsibility for this is shared by students, teachers, parents, and all education partners. Addressing these challenges begins with full and effective implementation of the mathematics Core Curriculum. This curriculum emphasizes:

- active learners of mathematics, using "hands-on" manipulatives and engaging in small-group settings to communicate and explore mathematics; and,
- interesting and relevant problem situations where students learn and apply new concepts in a variety of settings, including exploration using computers or cooperative learning structures.

Concerted efforts are required to bring these curricula initiatives to life in the classroom. Students must be given the opportunity to engage in meaningful learning activities which effectively use manipulatives, small groups, and computers.

Students must come to class ready and committed to learn. This includes a commitment to stay on-task, a persistence to do their best, and a responsibility to do necessary amounts of homework to integrate and apply concepts and to extend classroom learning.

Parents and teachers need to discuss with and help students in the development of these characteristics and the understanding of mathematics. It is important that lines of communication between students, parents and teachers are open. This includes both formally scheduled conferences and informal discussions and notes.

There is a strong relationship between students' attitudes and their achievement. By becoming active learners in a variety of settings, many students will enjoy mathematics more and perform better, or they will perform better and enjoy mathematics more.

Appendix A: Test Design and Results in 1997 and 1995

The *1995 Provincial Mathematics Learning Assessment* tested students mastery of mathematics concepts, procedures, and relationships; and their application and problem-solving skills. This was accomplished using paper-and-pencil and performance-based tests. Test items are connected to curricula objectives to closely measure students' skill-mastery within each curricula strand. Students completed practical performance tasks for particular mathematics skills.

The 1995 test items and practical performance tasks provided a basis for the design of the *1997 Provincial Mathematics Learning Assessment*. Computation and multiple-choice tests used a subset of questions from 1995. These were field-tested and refined again in fall 1996. Use of similar test items permits comparisons in student achievement outcomes between 1997 and 1995.

Figure 33: Grade 5 Average Scores for Computation Skills and Content Skills, 1997 and 1995 Provincial Mathematics Learning Assessments

	1997 Results	***1995 Results***
Computation Skills	63% (± 2%)	66% (± 2%)
Multiple-choice - overall	52% (± 2%)	56% (± 2%)
- whole numbers	62% (± 2%)	61% (± 2%)
- fractions	36% (± 2%)	44% (± 2%)
- geometry	31% (± 2%)	38% (± 2%)
- measurement	59% (± 2%)	66% (± 2%)
- data management	75% (± 2%)	75% (± 2%)

Note: Percentages are calculated only for sets of similar questions. Caution is required in drawing conclusions between achievement in the two years. Although questions were similar, some modifications were made to many of them. Students encountered the questions in different combinations and other differences were present.

Overall, Figure 33 shows that Grade 5 student achievement results related to computation and content-mastery skills are similar for 1997 and 1995.

Significant changes were made to the performance-based tests and the problem-solving test. For 1997, these tests were re-designed to further emphasize initiatives of the mathematics Core Curriculum. Particularly, test items demanded a wide range of application of skills that integrated several curricula concepts. This was different than the 1995 tests, where test items reflected discrete curricula objectives. Also, direct comparisons between 1997 and 1995 student achievement are not possible for these tests because of:

- refinement of achievement level criteria;
- substitution of the national *School Achievement Indicators Program* Mathematics Assessment at Grades 8 and 11;
- simplification and improvements of test administration procedures; and,
- renewed standards for achievement.

Although direct comparisons cannot be made, the adequacy of student achievement on the problem-solving and performance-based tests can be judged by comparing it to the standards.

Appendix B: Sample Size and Profile

Participating schools were randomly selected from the list of provincial schools teaching the Saskatchewan curriculum with Grade 5, 8, and 11 students. Selection criteria produced a random sample which proportionally represented rural, urban, and northern schools. Schools of varying population were represented.

Criteria excluded selection of:

- schools that field-tested the assessment tests;
- small schools that participated in the national *1997 School Achievement Indicators Program Mathematics Assessment*;
- very small schools that participated in the *1996 Provincial Reading and Writing Learning Assessment* or the *1996 School Achievement Indicators Program Science Assessment*; and,
- schools in *conseil scolaires francophone*.

A school could participate in only one component of the *1997 Provincial Mathematics Learning Assessment*. For the performance-based tests, a grade population of at least ten students was required. No minimum requirement existed for the paper-and-pencil tests.

Schools with fewer than thirty students in the chosen grade had all eligible students participate. Schools with more than thirty students selected a class of at least 25 students.

Students enrolled in regular mathematics programs participated. Students in modified programs, where foundational objectives of the course were altered, did not participate. In other words, students in special resource room programs, Mathematics 21, International Baccalaureate (I.B.) programs, or in locally-developed courses were not assessed. Regular program students requiring adaptations such as Braille, large-print, or scribes participated.

Figure 34 details the sample profile. The sample size permits reliable generalizations of results to the entire Saskatchewan student population sampled for the three grades.

	Grade 5		Grade 8	Grade 11
	Paper-and-Pencil Test	Performance Test	Performance Test	Performance Test
Total Schools Registered in Sample (March 1, 1997)	27	26	29	24
Total Schools Participating in Assessment (May 15, 1997)	27	24	29	24
Participation Rate of Schools	100%	92%	100%	100%
Total Students Registered in Sample (March 1, 1997)	633	612	650	620
Total Students Participating in Assessment (May 15, 1997)	615	527	612	528
Participation Rates of Students	97%	86%	94%	85%

Appendix C: Administrative Methods and Procedures

Selected schools and their school divisions were contacted in February 1997. Information bulletins containing the mathematics criteria and sample problems, outlined for teachers, parents and students the nature and scope of the assessment. Each school chose a coordinator to administer and return assessment materials.

In early April 1997, the *Handbook for School Coordinators* along with all test booklets and performance-based materials were sent to the school coordinators. A practice performance station with materials and instructions was included for all grades doing the performance-based test. The station prepared students and teachers for this type of an assessment. The *Handbook for School Coordinators* acted as a guide to:

- ensure the security of assessment instruments;
- prepare students for the assessment;
- allow for adaptations such as large-print forms, scribes or other special needs;
- set up the performance-station testing-room;
- provide instructions for the completion of questionnaires and assessment forms;
- ensure consistent administration of the tests related to time, breaks, independent student work, and the type of assistance they can give; and,
- ensure student work is properly handled to guarantee student, teacher, school, and school division anonymity.

The assessment was done between April 28th and May 16th in the regular classrooms. School coordinators returned all test booklet materials for scoring, but kept the performance station materials for future use.

Appendix D: Scoring and Data Analysis

In July 1997, seventeen mathematics teachers and consultants, working in two supervised teams, scored student work. One team scored Grade 5 problem-solving and performance-based booklets. The other team scored Grade 8 and Grade 11 performance-based booklets. These teachers were selected to reflect the diverse school situations in the province, including urban, rural, and northern locations.

The scorers assessed a number of elements in the problem-solving and performance-based test booklets. Holistic scoring sessions determined each student's overall achievement. Scorers assigned one of *Levels 1* through *5* which best described the quality of a student's overall work. To facilitate fair and reliable holistic scoring, the following procedures were used.

- Scorers studied the criteria which defined each of the five achievement levels. They examined the tests to see how the items reflected the criteria.
- Examples of student work (exemplars) showing proficiency at each achievement level were chosen and used to serve as references for scorers.
- Training sessions using the criteria, exemplars, and practice booklets developed consistency for judging student work.
- Scoring leaders continually monitored the process for consistency and provided adjudication when necessary.
- Scorers coded achievement levels on computer scan sheets. Consequently, re-scoring of the booklet and scoring of other elements of the student's work were not prejudiced by the first issued score.
- About 20% of the booklets were scored twice. The comparative scores were analyzed for team scoring consistency.

The Grade 5 scoring team achieved a 0.81 reliability on a 20% sub-sample of student booklets scored twice holistically. The Grade 8/11 scoring team had a 0.67 reliability measure.

Next, the scoring teams viewed the performance-based test booklets for mathematics communication proficiency. For this element, student work was judged into one of three levels: *Beginning Communication*, *Adequate Communication*, or *Proficient Communication* in mathematics. Specific criteria and student exemplars related to written mathematics communication were used. Otherwise, scorers followed the same procedure for scoring this element as described above.

For scoring written mathematics communication, the Grade 5 scoring team achieved 0.68 and the Grade 8/11 scoring team achieved 0.52 reliability scores.

Finally, the two scoring teams analytically scored specified performance stations. Most stations contained five questions, assessing some criteria at each of *Levels 1* through *5*. For most questions, scorers coded each student response with one of five codes as follows:

Code A- student's response is correct and shows sufficient justification;
Code B- student's response is correct but does not show sufficient justification;
Code C- student's response is incorrect but shows clear understanding of the mathematics criteria being tested (a transcription or computation error was probably made);
Code D- student's response is incorrect and the student does not show understanding of the specific mathematics criteria being tested; and,
Code E- no mathematical response was attempted.

Scoring templates containing criteria and evidence for each question and examples of coded student work provided training for the analytic scoring of a station. After scoring all student booklets for one station, scorers were trained to code the next station.

Scoring teams achieved the highest reliability when doing this analytic scoring. The Grade 5 team averaged 93% agreement when booklets were scored twice analytically. The Grade 8/11 team averaged 86% agreement for their double-scored booklets.

Scorers were asked to guard against bias for unattractive handwriting, incorrect grammar, poor spelling, and any factors other than the mathematics quality of the answers.

The coded computer sheets for the problem-solving and performance-based tests were scanned into a statistical data base. Student multiple-choice responses, computations, and questionnaire data were all entered into the data base. Teacher questionnaire data were also entered.

Item and test analyses were performed for each questionnaire and assessment form. Response patterns, item difficulty, discrimination indices, average scores, frequency distributions, and measures of test reliability were computed. Cross-tabulations and tests for significant variations were done for some test and questionnaire variables.

Appendix E: Standard-Setting Procedures

Standard-setting involves stating expectations for provincial student achievement for a specific set of tests. Standards or expectations are not fixed or static. Expectations will vary according to the complexity of the test questions and tasks, the criteria used for scoring the test, the attributes of the student population being tested, and the composition of the committee setting the standards.

The standards serve to place an interpretive framework around the data, to highlight the strengths and weaknesses in student achievement, and allow the public to confidently judge the adequacy of the assessment results. Such standards have been established for previous provincial reading, writing, and mathematics assessments and for national science and mathematics assessments. The standards remain in place for discussion and comparison with the results until new standards are set to accompany the next cycle in the assessment.

In addition to the student achievement standards, stakeholder representatives convened for the first time to establish opportunity-to-learn standards for eight elements of learning mathematics.

Who set the standards?

Twelve stakeholder representatives sat as two panels of judges to set standards. One panel set achievement and opportunity-to-learn standards for Grade 5, the other for Grades 8 and 11. Stakeholders invited to participate included:

- Saskatchewan Teachers' Federation;
- Saskatchewan School Trustees Association;
- League of Educational Administrators, Directors, and Superintendents;
- Saskatchewan Association of School Councils;
- Saskatchewan Chamber of Commerce;
- Saskatchewan Indian Federated College;
- University of Saskatchewan, Faculty of Education;
- University of Regina, Faculty of Education;
- Gabriel Dumont Institute;
- University of Saskatchewan, Student Union; and,
- University of Regina, Student Union.

In what areas were standards set for student achievement?

Panels first set achievement standards by realistically considering the percentage of students they would expect to attain each of the achievement *Levels 1* through *5* for the following:

- overall achievement for Grade 5, 8, and 11 performance-based tests;
- overall achievement for the Grade 5 problem-solving test;
- achievement for the *Win or Lose* performance station for each of Grades 5, 8, and 11.

The last set of achievement standards were set around students' proficiency in written communication in mathematics. For these, panelists identified the percentage of students they would expect to exhibit *Proficient Communication*, *Adequate Communication*, and *Beginning Communication* at each of Grades 5, 8, and 11.

What questions did panelists consider when setting opportunity-to-learn standards?

Panelists set opportunity-to-learn standards for each of Grades 5, 8, and 11 considering eight questions. The first four questions yielded a number of times or amount of time each week that students engage in various practices. Panelists stated expectations for a typical week:

- the **least** number of times that Grade X students would use concrete manipulatives to help understand ideas and solve problems in mathematics;
- the **least** number of times that Grade X students would use the computer as a resource for learning mathematics;
- the **least** number of times that Grade X students would work in pairs or small groups in mathematics classrooms; and,
- the average amount of time Grade X students would spend doing meaningful homework.

For each grade, the final four questions yielded percentage expectations of students:

- who keep trying hard, using different strategies, and persisting until they solve difficult mathematics questions or do as well as they can;
- whose parents regularly attend school interviews or conferences;
- whose parents regularly discuss their academic progress with them; and,
- whose parents help them with school assignments.

What process was used to set the standards?

Panelists set achievement and opportunity-to-learn standards using a three-round voting process. Panelists:

- reviewed test instruments, criteria, student exemplars, or background document to better understand the context of the standards question;
- made initial judgments for the question using private ballots;
- discussed differences in their judgments after viewing the voting-distribution pattern of the panel;
- made second-round, private judgments for the same question considering elements of the discussion;
- viewed a comparison of their second-round voting pattern with actual student outcomes or practices and discussed factors which may explain any differences; and,
- made their final third-round, private judgments for the same question.

The average of the panelists' third round of judgments becomes the standard for the question. The process is repeated for the next achievement- or opportunity-to-learn-standard question.

Appendix F: Mathematics Assessment Criteria

For this assessment, student achievement is classified into one of five levels. Below are **some** characteristics and practices of students achieving the different levels. Not every characteristic need be present to identify a student at a given achievement level. Also, the level of difficulty of a given problem and the assumed students' exposure to the concepts in the problem are factors in the classification of a task as being simple or complex. Typically,

- *Level 1* tasks might involve problems dealing with concepts introduced in the curriculum in previous years;
- *Level 2* tasks might involve problems dealing with more difficult concepts introduced in previous years or simpler concepts introduced in the current year;
- *Level 3* tasks might involve problems dealing with many of the concepts introduced in the current year;
- *Level 4* tasks might involve problems dealing with difficult combinations of concepts dealt with in the current year; and,
- *Level 5* tasks might involve problems requiring insightful treatment of concepts that would challenge the very best mathematics students of this grade.

Students achieving *Level 1* proficiency can be expected to:

- follow explicit directions for limited-step procedures;
- use concrete materials (manipulatives) to perform simple operations;
- solve one-step operational problems;
- extract single pieces of data from simple tables;
- show a limited understanding of very commonly used mathematics terminology;
- order data by size (or quantity);
- make some accurate, simple measurements.

Students achieving *Level 2* proficiency can be expected to:

- make simple conclusions directly from a table of information;
- extract data directly from a table or from the simple use of concrete materials, and select and perform a simple operation on the data;
- follow explicit directions for prolonged or more complex procedures;
- show a basic understanding of commonly used mathematics terminology;
- find more than one solution, using manipulatives, to a simple, multi-solution problem;
- use common language to explain strategies (poorly communicated requiring significant reader interpretation);
- use manipulatives without directions to solve simple problems;
- use given formulas to operate on numbers;
- identify basic number pattern relationships (arithmetic sequences);
- make consistent accurate measurements (length, mass, volume).

Students achieving *Level 3* proficiency can be expected to:

- graphically represent data from a simple data table;
- persist to execute instructions for prolonged, complex procedures;

- extract more than one piece of data from a table, and select and perform complex or multiple operations on the data;
- explain strategies and conclusions with common language and some mathematics terminology (requires little interpretation by the reader);
- identify an additional strategy for solving a problem;
- create simple manipulatives to solve a given problem;
- abstract beyond given information or materials to solve minor extensions of problems;
- solve multi-step problems;
- use basic number patterns to interpolate and/or extrapolate data;
- calculate ratio relationships.

Students achieving *Level 4* proficiency can be expected to:

- clearly explain strategies and conclusions using appropriate mathematics terminology (requires no interpretation by the reader);
- make predictions based on given data and justify the predictions with clearly communicated rationale;
- identify alternate strategies and use the "best" strategy for solving a problem;
- use manipulatives in unique, innovative ways to solve problems;
- create manipulatives to help solve complex problem extensions;
- abstract beyond given information or materials to solve significant extensions of problems;
- solve complex, multi-step problems; find more than one solution (if possible); state assumptions leading to solutions (or non-solutions) of the problem;
- identify and use more complex number patterns to extrapolate information and/or find solutions to problem extensions;
- conclude relationships (or lack of relationships) between measured quantities and justify these conclusions;
- identify errors in logic, explain reasons leading to invalid conclusions, and where possible, correct the logic to arrive at valid conclusions;
- appropriately generalize findings and conclusions, using clear-language rules, algebraic equations, and/or statistical considerations;
- interpret graphically-presented information to draw conclusions about complex real-life situations.

Students achieving *Level 5* proficiency can be expected to:

- clearly and concisely explain strategies and conclusions using accurate mathematical terminology (may use some symbolic notation);
- produce extensive, complete work that communicates conclusions in light of assumptions made;
- insightfully create and/or use concrete manipulatives, original algorithms, or heuristics to find solutions to complex problems requiring consideration of several criteria;
- find several solutions to problems with a number of possible solutions;
- try a variety of strategies and persist to solve complex, non-routine problems;
- solve and explain extensions of problems in light of newly established relationships;
- clearly explain reasons for number patterns and relationships referencing mathematical concepts;
- solve complex problems beyond grade-level expectation.

References

Epstein, J. L. (1988). *Homework practices, achievements, and behaviors of elementary school students* [Report No. 26]. Baltimore, MD: Center for Research on Elementary and Middle Schools.

Ernest, P. S. (1994). *Evaluation of the effectiveness and implementation of a math manipulatives project.* Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Nov 9-11, Nashville, TN.

Hunter, D. M., Jones, R. M. & Randhawa, B. S. (1996). The use of holistic versus analytic scoring for large-scale assessment of writing. *Canadian Journal of Program Evaluation 11* (2): 61-85.

Jaeger, R. M. et al. (1993). *Integrating multi-dimensional performances and setting standards.* Paper presented at the Annual Meeting of the National Council on Measurement in Education, Apr 13-15, Atlanta, GA.

Jones, R. M. & Hunter, D. M. (1996). Setting achievement standards/expectations for large-scale student assessments. *Canadian Journal of Program Evaluation 11* (1): 35-61.

Kanter, P. S. (1994). *Helping your child learn math* [WWW document]. Online. URL http://www.ed.gov/pubs/parents/math.

Mathematical Association of Victoria. (1997). *Mathematics problem solving task centres* [WWW site]. Online. URL http://www.srl.rmit.edu.au/mav/PSTC.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

Porter, A. (1995). The uses and misuses of opportunity-to-learn standards. *Educational Researcher 24* (1): 21-27.

Saskatchewan Education. (1988). *Understanding the common essential learnings: A handbook for teachers.* Regina, SK: Author.

Saskatchewan Education. (1992). *Mathematics: A curriculum guide for the elementary level.* Regina, SK: Author.

Saskatchewan Education. (1995). *Mathematics: A curriculum guide for the secondary level.* Regina, SK: Author.

Saskatchewan Education. (1996). *Mathematics: A curriculum guide for the middle level.* Regina, SK: Author.

Saskatchewan Education. (1996). *Mathematics A 30, B 30, C 30: A curriculum guide for the secondary level.* Regina, SK: Author.

Saskatchewan Education. (1996). *1995 Provincial learning assessment in mathematics.* Regina, SK: Author.